Industrial QUALITY CONTROL

MARCH, 1953 VOL. IX, NO. 5

AMERICAN SOCIETY FOR QUALITY CONTROL

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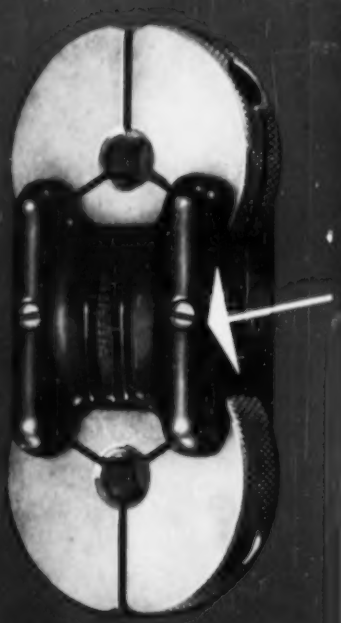

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October 28, 1952

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E.C. Barnhardt
Quality Control Superintendent

ECB/jk

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3 **Quality levels of their different products are easily compared.**

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Industrial Quality Control

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RECENT TRENDS IN QC

While our Society continues to grow rapidly in membership and influence, it seemed desirable to set down a few trends in Quality Control which seem to be taking place. This list is not exhaustive, but should be thought-provoking.

1. There seems to be a more realistic relationship developing between producers and consumers. The latter are becoming more willing to go so far as to pay for some defectives, to admit that one cannot expect perfect lots and to set Acceptable Quality Levels above zero percent. Defects are being classified, and only the truly important defects given full attention. More and more, appeal is to the facts obtainable only by sound sampling and measurement. Vendor certification is growing.

2. We are seeing the growth of acceptance sampling for variables, to supplement attribute plans. Many basic details are yet to be worked out, but it is seen that sound plans can be "canned" when we know at least something about the distribution of the lot characteristic.

3. Defects-per-unit plans are more available and closely integrated with defectives plans.

4. There seems to be less emphasis on the Average Outgoing Quality Limit, which may not be an altogether desirable trend.

5. Speakers and executives seem to be stressing less the dollars savings accomplished by Quality Control, and more the advantages gained in developing quality-mindedness, pride of workmanship, cooperation and team-work.

6. We are seeing ever wider applications of Statistical Quality Control to all types of products and to all departments in a plant, from clerical to inventory and sales.

7. Applications are rapidly growing in continuous and batch process such as those in chemical and metallurgical industries.

8. There continues to be no appreciable trouble from organized labor. This is a tribute to the care and imagination with which SQC has been introduced and the far-sighted outlook of labor leaders.

9. Adaptations of, and experimentation with, control charts are being made, such as the use of $\tilde{X}$ charts, median center lines for range and σ charts, and various ways of calculating control limits for special cases. These only serve to confirm our confidence in Dr. Shewhart's basic control chart philosophy and technique.

10. Many papers are being written to chink in the gaps in our knowledge, and to answer questions raised in applications.

11. The capabilities of machines and processes are beginning to be much better known. Some plants even go so far as to pay for a machine only after it has been proven capable of meeting the tolerances claimed for it, as well as meeting its claimed production. This trend should cause no fear in the manufacturer of a quality machine. It can only hurt the manufacturer with a poor product or overzealous sales staff.

12. There seems to be less fear, and wider use, of so-called "advanced" methods. Statistical knowledge is spreading.

13. Engineers of all types, and both in industry and universities are becoming more aware of, and better trained in, the statistical approach to problems.

14. There is evidence of better designed and more efficient experimentation, both industrial and research.

I. W. B.

OUR COVER

This month we are indebted to Mr. W. H. Smith, Ford Motor Company, Dearborn, Michigan for our cover picture which is one of the illustrations of his article appearing in this issue. This picture shows the front suspension linkage assembly in place in the setting fixture. At the right are shown the control charts on this operation.

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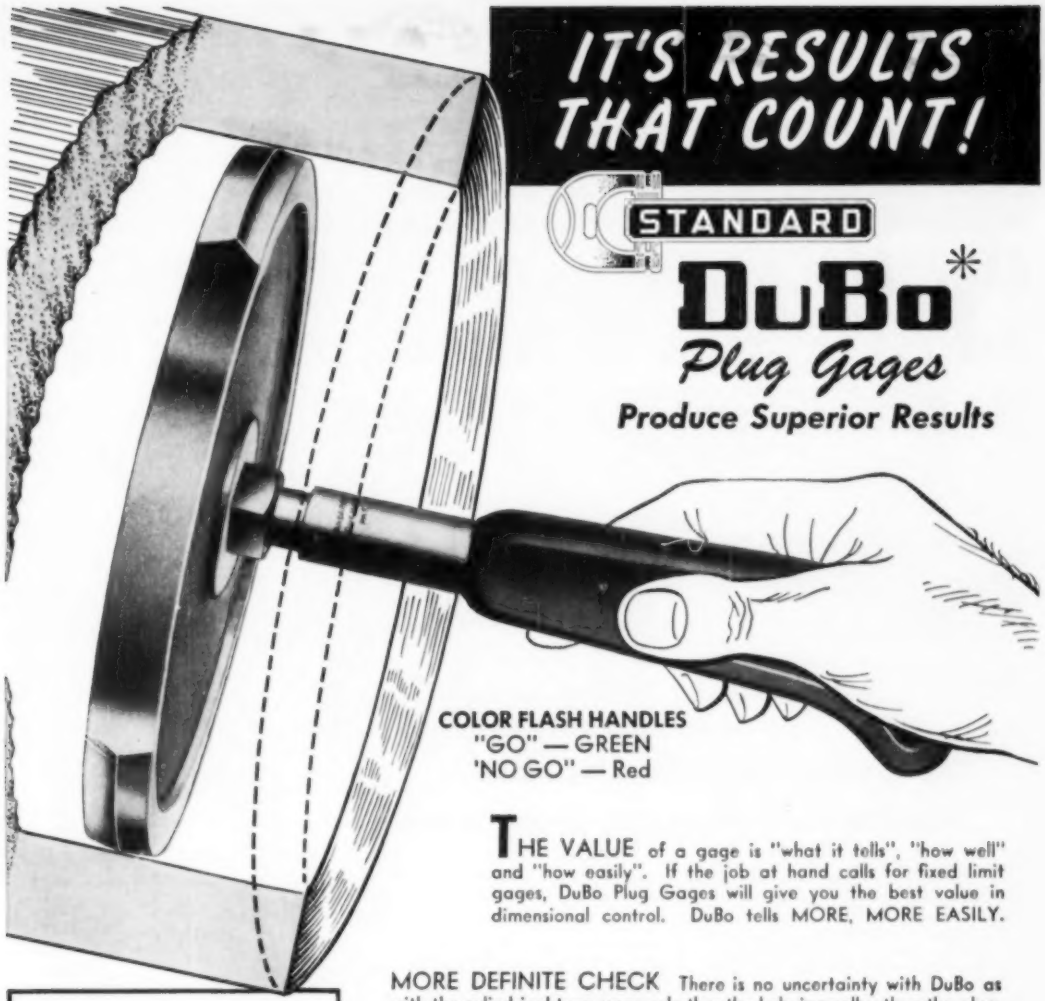

COLOR FLASH HANDLES
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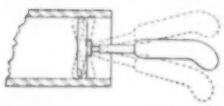

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Whether handle will drop freely or not is the definite yes-or-no indication. No guesswork, no forcing, no fumbling!

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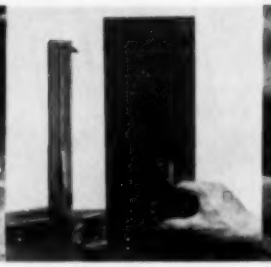
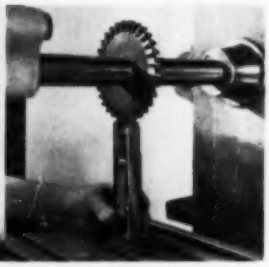


Straight line scribing done with Micro-Step. Gage Block setup.



Setting milling cutter. A carbide wear block is used to protect the gage.

Gage-Block Gages Quickly Assembled with New DoALL Micro-Step Gaging System

A new Micro-Step Gaging System, developed by DoALL, has taken gage blocks out of "mothballs", released them from captivity as the "jewels" of the inspection department, and put them to work in *direct* measurement of parts and machine settings in the toolroom and shop. For the first time, industry can fully utilize the millionths accuracy of these "measurement masters" to reduce errors, speed up gaging and eliminate the high cost of many special gages. Now gage blocks can be used practically and profitably as working tools. Gone is the day of keeping them under lock and key where their value and usefulness lay dormant most of the time. On the basis that idle tools make no money, DoALL has developed a method of creating dividends on gage block investments.

Essentially, the new System provides a means of quickly assembling an infinite variety of gages and layout scribers incorporating standard rectangular (USA type) gage blocks. These precision *gage-block gages* are then used for direct measurement. Typical instruments which can be assembled include indicating comparators, snap gages, go and no-go gages, internal gages, pin gages, depth gages, various scribers and many others.

Components

The components of the Micro-Step System are:

1. **Holders**—channel type for holding gage blocks in heights up to 72" or more; a unique caliper holder for setups to 6" is ideal for making outside and inside calipers, dividers, scribing compasses and others.

2. **Fully Exposed End Standards**—specially designed functional gage blocks provide the actual measuring surfaces of the assembled gage. The *unobstructed* surfaces extend beyond the ends of the holder, permitting innumerable setups never before possible with gage blocks in holders.

3. **Pre-calibrating Dial Indicators**—for making indicating *gage-block gages*.

4. **Gage Blocks**—DoALL, or any standard USA type.

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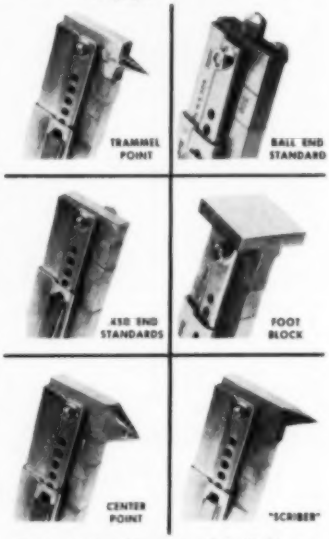
The design of the Micro-Step Gaging System prevents excessive wear of the gage blocks themselves. The blocks are not subjected to the sliding, wear-producing action of manual wringing, but are wrung together by moderate pressure of the holder clamps. Nor are they subjected to damaging contact with the part being measured.

Complete information regarding the DoALL Micro-Step Gaging System has been incorporated in a new Bulletin available upon request.



Some of the Micro-Step End Standards available.

GB-14

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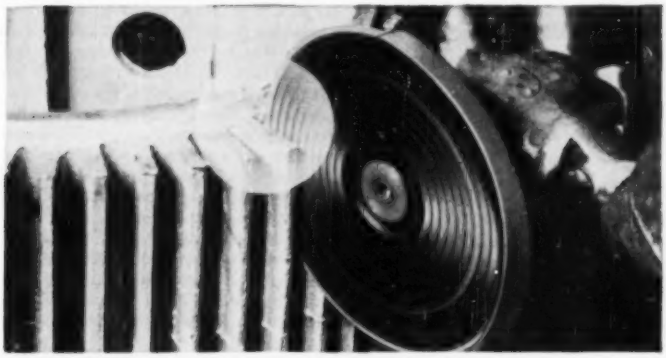
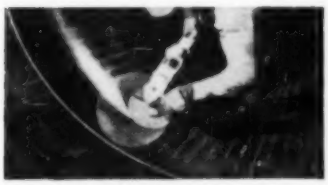


CLEANING OUT FINS of a compressor casting is a hard job made easy — when you use a Norton BD rigid hub wheel.

NEW!... The Norton BF Wheel For Light Finishing

Meet the latest Norton development for your lighter finishing jobs. Basically, the new BF wheel is built like the BFR wheel but is designed especially for periphery grinding. You'll find its flexibility in the softer grades (G and I) ideal for blending and smoothing curved surfaces and corners. The hardest grade (K) is more rigid — best for light welds and sharp edge applications. In all grades it tends to finish as it cuts.

Like the BFR and BD wheels, the new BF wheel cuts fast and free and has a high safety factor. Like them, too, it features versatility, covering a range of usefulness that includes finishing stainless steel welds, deburring metal parts such as stampings and removing gates and fins from molded plastics. Let the new BF wheel add "The Touch of Gold" to many of your own light-duty grinding jobs.



Smoothing welds in a fabricated cone — semi-flexible BFR

Notching risers on gray iron castings — either type

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W-1472

Problems of Receiving Inspection and The Assembly Line*

W. H. SMITH

Ford Motor Company

SOME of what is in this article is very likely to be "old hat" to a number of you. The QC techniques discussed are certainly not new to anyone who is conversant with standard methods of statistical quality control. But our experiences, as reflected in a few problems and case studies may be stimulating, inasmuch as they come from high volume operations where even the smallest quality improvement pays off in a substantial way.

Figure 1 shows, in a very elementary fashion, how QC fits into the flow system between the receiving docks and the manufacturing departments. Inasmuch as QC is a preventive program, it should be noted that receiving inspection, if it is to be most effective, must take place before parts and materials reach the storage area. This is found to be one of the most critical decisions facing a newly organized QC program: Not only must a sampling plan be instituted on received parts, but there may also have to be some pretty drastic changes with regard to the flow of stock and the storing of uninspected shipments in the stock rooms. We hold to the principle that materials should be "accepted" into stores in the full sense of the word accepted. This means that they should not be inspected in transit from the stock room to the point of use—or worse still, in direct transit from the receiving dock to the point of use. Many advantages were found in the "Bond Room" setup which so many of us used in defense jobs during World War II, and these lessons should not be forgotten.

A particular advantage to making quality determinations prior to storing is found in the promptness with which the suppliers can be urged to solve quality problems that arise. If receiving inspections are to serve the two-fold purpose of quality protection and quality improvement, too much emphasis can not be laid on the prompt inspection of shipments upon receipt. Another important consideration is that materials should be handled in the stock room on a "first in, first out" basis. Without such a provision, it is impossible to handle adequately campaign corrections or design changes with which even the best QC system will occasionally be faced.

Let's study the figure a little more to see what can and does happen with a poorly organized receiving program. The upper flow chart depicts the kind of haphazard system which almost invariably results from the lack of either a plan or a desire for quality control. Incoming stock can travel along any of a number of avenues, most of which result in leakage of defective parts to the manufacturing area—or even in the outright misdirection of entire rejected shipments to manufacturing. Any bin of parts becomes fair prey, regardless of its location and quality disposition, for the fellow in the manufacturing department whose job happens to be in desperate shape for lack of material. And believe me, as long as the pallets or boxes are not nailed to the floor, that is exactly what happens under such a system.

Inspection, in these circumstances, can only be weakly effective at best, and many of the inspections, however capably performed, are futile from the standpoint of furnishing sound materials to the manufacturing department.

Now let us say that the condition represented as "good" in the figure has been achieved. Observe that there is no leakage, and that inspected shipments can go in only two directions, either to "OK stock storage" or to "rejected stock storage." If parts are on critical shortage, and the supplier nevertheless requires that any rejected shipments be returned, then it may be economical for the consumer to sort or to repair at his own expense in order to keep his jobs running. And even when parts are not on shortage, the supplier may for purposes of economy propose that rejected shipments be sorted or repaired at his own expense, rather than have them shipped back for credit. Arrangements of this kind generally work out to mutual advantage, but they must take place under a tight system of control in which reinspection or sortings finally result in the forwarding of sound materials to OK stock storage.

It is well, also, to consider the nature of the inventory on hand under the "good" and "poor" systems depicted here. Under the latter, a very sizable portion of the inventory is of undetermined quality. The manufacturing department is likely to be working a good share of the time on a hand to mouth basis with inspection, since a large part of the float is literally floating instead of standing in stock storage ready for use. If

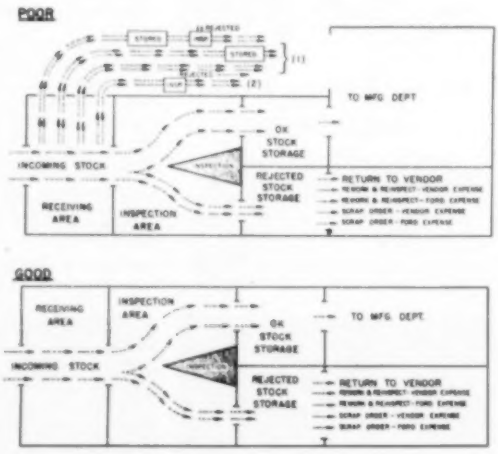

Figure 1—**Receiving Inspection Flow System**

*Paper presented at the Fifth Annual Convention of the American Society for Quality Control at Cleveland, Ohio, May 24, 1951.

incoming quality on a part goes seriously bad, there is likelihood that the part goes automatically on shortage, since a bank of acceptable stock is not available to see the manufacturing department through. But under the system depicted as "good," quality emergencies of reasonable proportions can be readily coped with because the inventory is so largely made up of inspected and dispositioned shipments.

The two and a half year old program for improved quality control at Ford has still to reach full maturity. We still have growing pains in abundance in trying to work toward the "good" system just described. But some amazing progress has been made in our large receiving locations—more than enough to prove that the goal of an improved receiving inspection system is a most worthwhile thing to go after. A little later I will give you some before and after figures on one of our receiving inspection jobs, but first I want to talk about acceptance sampling.

THE FAULTS OF RECEIVING INSPECTIONS

As many of you know, acceptance sampling generally has to do with receiving inspection, though the same methods may also be used as a summary check on end-product quality before shipment is made.

If your company has been anything like ours in years gone by, its receiving inspection varied in degree between two wide extremes. Some incoming shipments were regularly inspected 100 percent because there was a history of poor quality on the parts. That was one extreme. At the other extreme was only the verification that the contents of the shipment were properly identified on the shipping label. Generally, though, receiving inspection fell some place between these extremes. Standard practice in some firms, for instance, continues to be ten pieces per shipment, regardless of how large or small the shipment might be.

Figure 2 shows a group of our vendor representatives witnessing a demonstration of the risks involved in such a fixed sample plan. The box contains 1000 marbles, 50 of which are red, or defective, and 950 white, or acceptable. This, then, represents a lot of 1000 pieces which is exactly five percent defective. Our visitors found out, somewhat to their surprise, that repeated ten-piece samples contained not a single defective on more than half of the tries. In other words, a good majority of the time, such a five-percent defective lot would be passed by the inspector if he only examined ten pieces. There would actually be a greater chance of rejection if he passed judgment by the flip of a coin —heads we keep the shipment, tails we send it back.

Figure 2—Demonstrating the Risks of a Fixed Percentage Sampling Plan to a Group of Vendor Representatives

Other firms, recognizing that the sample size should in some measure be dependent on shipment size, use a flat five- or ten-percent sampling inspection plan. This is evidently done in the mistaken belief that every shipment is thus subjected to an equally rigid testing, regardless of its size.

A good look at this method reveals some interesting things about varying risks. In fact, they are more than interesting—they are staggering. Table I is a modification of a chart which appeared in the book titled "A Basic Training Manual on Statistical Quality Control."

TABLE I—**Ten Percent Sampling Plan on Five Percent Defective Shipments**

Lot Size	10% Sample Size	No. Accepted out of 100 Lots	Ideal No. Rejected out of 100 Lots
100	10	60	100
200	20	37	100
1000	100	1	100

It is used by the kind permission of the authors, Rudolph Freedman and Joseph Movshin, who are associated with the St. Louis Section of ASQC. In this table are presented the results of a study on three shipments of varying sizes, each of which was exactly five percent defective and each of which was submitted to a ten-percent inspection. The shipment was rejected if even one defective was found in the sample, since that is how many of these ten-percent plans work.

The amazing results of this series of inspections are shown in the third column. Observe that the risks of accepting rejectable lots are ridiculously different, comparing the largest lot to the smallest. If a supplier ships in lots of 1000, he gets knocked down 99 times out of 100 for a five percent defective shipment. But if he ships in lots of 100 pieces, he only gets caught 40 times in 100. I would hate to have to justify this sampling plan to three suppliers, each of whom for his own reasons regularly shipped in only one of the lot sizes shown.

The inconsistency of these two sampling methods, flat ten piece and flat ten percent, stems from the fact that neither approach recognizes the risks which are present to some calculable degree in any sampling plan, even the best. A well-regulated flow system, such as that discussed at first, makes only a meager contribution to quality control if a sound sampling technique is not used to check the shipments through.

RECEIVING INSPECTION BY ACCEPTANCE SAMPLING

True acceptance sampling is just a more intelligent approach to this same problem of making quality judgments on the basis of examining representative samples. Risks are calculated so that inspections made according to the plan will, with predictable certainty, be good guides for the judgement of incoming shipments.

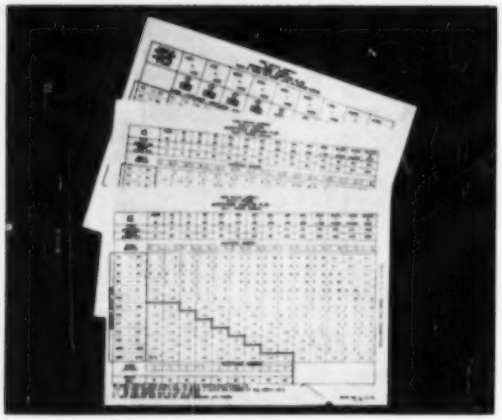

Figure 3—**Ford Sampling Tables**

Acceptance sampling, since it is based on known risks, is an inspection method for attaining the maximum in quality assurance with a minimum in inspection effort. We all know that you can't afford to employ 100 percent inspection on every incoming shipment. And since you cannot afford 100 percent inspection, the compromise is actually one of quality assurance versus inspection effort. Acceptance sampling is designed to balance these so that the most economical sampling is made which is consistent both with the kind of quality you feel you ought to have and with the risks you can afford to take in determining whether or not the desired degree of quality is being met.

It comes as a rude surprise to many who are not in this kind of work to know that a manufacturer, while he desires perfection in his incoming shipments, may feel that he can afford to live with shipments which are on the average as much as two percent defective. The philosophy of acceptance sampling has to do with realism—I can't get perfection from my suppliers; neither can I afford to screen out each and every defective. I must therefore employ an inspection method which will require the least inspection effort in my plant to ensure that my suppliers do not with any frequency exceed the amount of defectiveness I can afford, in the long run, to absorb in successive shipments.

Maybe this level of defectiveness is two percent and maybe it is one-half percent, depending on the importance of the particular quality characteristics and parts involved. But at any rate the decision has to be made. If you can't bring yourself to this decision, then you can't enjoy the benefits of acceptance sampling. The desired quality is called the acceptable quality level or AQL for a given part.

THE FORD ACCEPTANCE SAMPLING PLAN

The three 8½ by 11 inch tables in Fig. 3 represent the Ford Acceptance Sampling Plan. After some months of experiment and experience with a variety of plans, we adopted one which was published by the Armed Services in the Joint Army-Navy Standard-105. This is a book of sampling tables and risk curves which covers a fairly wide variety of plans. It was of course necessary to reduce the plan to a more usable form for our inspectors, and to include only those portions of the manual which described the single- and double-sampling techniques that we wanted to employ.

Briefly stated, under the single-sampling plan the inspector either accepts or rejects the shipment depending on the number of defective parts found in a single random sample. Both the sample size and a limiting value for the number of allowable defectives are found in the table. These are varied depending only on two factors, (1) the size of the shipment, and (2) the acceptable quality level, or AQL, which the consumer has elected to use. Double sampling is the same idea carried to two stages for the sake of long run inspection economy.

A typical receiving job is shown in Fig. 4. Notice that the inspector's instruction sheets, blueprints, and the sampling tables are there before him. Figure 5 shows a receiving area. Note that the sampling tables have been framed, for convenience, on the wall at each bench.

Figure 4—**A Receiving Inspection Job.**

Figure 5—**A Receiving Inspection Area.**

Now a word about increased inspection efficiency under an orderly program for quality control at receiving. The following statements concern the experience of the largest production parts receiving center in the company; and I should preface the results by repeating what the QC supervisor told us. He said that his gains resulted from:

First: "the complete cooperation of people responsible for routing incoming materials through the receiving areas to stores."

Second: "the adoption of the standardized acceptance sampling plan."

Third: "the training of inspectors in the use and understanding of the acceptance sampling tables."

And here is what happened: In the month of August 1950, after about a year of experience with the new QC system in receiving inspection, the shipment coverage of the average inspector had increased in the ratio of one to five. In other words, where one shipment had been inspected and judged in June 1949, five were being judged in August 1950, making it possible for us to obtain a far more thorough coverage of receivals with no increase in inspection manpower, floor space, or equipment.

Before leaving the subject of receiving inspection I want to mention the planned use of the great body of quality information accumulated under an orderly acceptance sampling plan.

Not only are we able to judge individual shipments, but we are able also to put inspection results to work in the form of quality trend charts. The kind of chart shown in Fig. 6 has hundreds of counterparts all over the Ford Motor Company. Plotted at regular intervals on a given part from a given supplier, each chart sums up from period to period the total percent of defectives found in all first samples drawn in the period.

Charts such as these are kept, mainly, on incoming quality problem parts. Copies are regularly furnished by operations quality control managers to those responsible in the company for bringing about supplier improvement. Purchasing plays a most important role in this regard, and the comparative performance of each of several suppliers on a given part is an invaluable aid to the buyer in bringing the black sheep back into the fold.

Another interesting offshoot of acceptance sampling is Quality Level Certification. For instance, we, as a

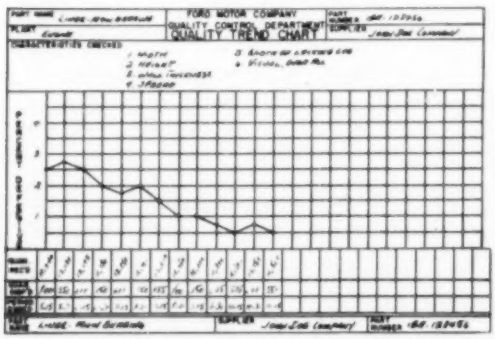

Figure 6—**Trend Chart On an Incoming Part**

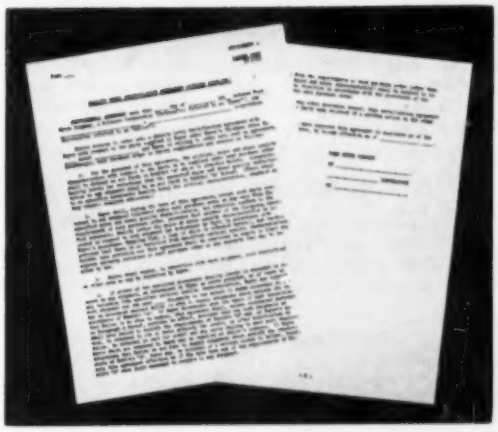

Figure 7—**Quality Level Certification Agreement**

consumer, modify our stated right to reject and send back to a supplier each and every defective item in any shipment. The Quality Level Certificate Agreement, shown in Fig. 7, is an attachment to the purchase contract wherein the vendor proposes to give continuous documented assurance that each of his shipments satisfies the requirements of an AQL which is *mutually* established as being reasonable. We, the consumers, inspect according to the standard Ford Acceptance Sampling plan and absorb, *at our cost*, the incidental defectives in any shipment which is found acceptable on the basis of the established AQL. And, of course, we return the shipments found rejectable. After the supplier gives adequate proof of his consistent ability to abide by the agreement, we are able to eliminate much of our inspection and only sample shipments infrequently in a quality audit.

The agreement is subject to cancellation if the supplier fails to achieve the consistent quality which he claims, or if for any other reason its continuance proves undesirable to either party. In the event of such cancellation, we revert to the specific powers of rejection embodied in the original purchase contract.

The question always follows—"Why formalize this procedure when an acceptance sampling plan seems to do the same sort of thing without formality?" The answer is found in three important areas. First, it is virtually impossible for any supplier to certify his shipments without using sound methods for process quality control. If he uses SQC effectively in his manufacturing processes, then both he and the consumer benefit in ways which should hardly require explanation. Second, the supplier and consumer must agree not only on an acceptable quality level, but also on the particular quality characteristics which are to be governed in the agreement. This may be the most important aspect of all—*to be able to agree finally on what is or is not important to the consumer from the standpoint of quality.* It follows automatically that the supplier can concentrate his quality control efforts on the particular characteristics of first importance to us. The third answer has to do with the psychology of a quality commitment. The urge of a supplier to stay with the agreement will be a strong factor in perpetuating the high quality that we,

at Ford, are most anxious to get from all of our suppliers.

We are only at the very beginning of a full-fledged Quality Level Certification program. After many months of experiment and testing, we entered into the first such agreement with a supplier during August 1950. Others are ready to follow, but we are moving into this area with a caution born of its relative newness in industry.

DRIVE SHAFT BALANCE

With regard to the next link in the chain, that of quality control on sub-assemblies, I have here a few case studies which may be of interest. These jobs had proved incapable of correction under old-time inspection methods, even though the solutions, as time later proved, seemed quite simple. You have heard, before, that quality control is only an organized approach to the analysis of inspection results. These examples are certainly cases in point.

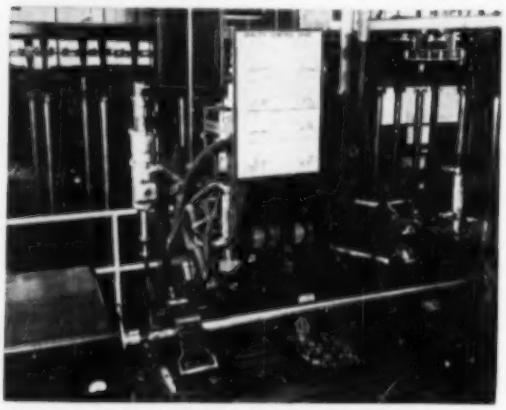

Figure 8—**Drive Shaft and Universal Joint Assembly in Balancing Machine**

The first case concerns the drive shaft and universal joint assembly. To insure proper operation in the car as well as to eliminate vibration and noise, it is necessary to balance this assembly. Each completed assembly is taken from the conveyor and placed in the production balancing machine—shown in Fig. 8—where it is revolved at 3200 rpm. The operator reads indicating dials which show the amount and angle of unbalance. He then welds counterweights to the tube of the shaft bringing the assembly into balance with a tolerance of ½ ounce-inches.

Before SQC was established, the process inspector selected balanced assemblies several times daily at random and tested them using one of the production balancing machines. If he found any out-of-balance assemblies, he rejected all work produced since his last check, and all pieces were returned to production for retest. This information was relayed to the job setter who then checked all of the balancing machines to make sure they were operating to the best of their capacities.

This situation resulted in a continual controversy between inspection and production as well as complaints from our assembly plants. In addition, balancing machines were often arbitrarily shut down for repair since they were blamed, sometimes indiscriminately, for the defective assemblies.

To bring this operation into satisfactory control, we first placed control charts at each machine. On the machine in Fig. 8 the control chart is directly in front of the operator. The method of inspection was changed so that the inspector now systematically selects a sample of five completed assemblies from each of the seven machines, checks each for unbalance, and records his readings for both the drive and axle ends on a worksheet. He then computes the *average* unbalance and the *range* of unbalance for each of the samples and plots them on the individual machine charts. If either the range or the average falls outside the control limits, the inspector puts the "Red (Out-of-Control) Hand" up. The operator or job setter then makes the necessary corrections to bring the job back into control. As long as the job remains in control, the operator gets the "Green (In-Control) Ball" which signifies that it is okay to proceed with production.

In addition all concerned personnel were instructed about how the inspector takes his samples, computes averages and ranges, and plots the control charts.

Preliminary data disclosed that both the average and the range portions of the charts were out-of-control. They were consistently running with more variation than the blueprint allowed. The averages were quickly brought into control by the operators once their errors were pointed out to them. They soon learned to work closer to zero than to the maximum allowable limit.

The range, or variation from piece to piece, was found to be much more difficult to adjust to a satisfactory level. Further study of this operation showed several weaknesses in the process, and resulted in clearly demonstrating to management the need for providing heavier balancing machine cradles, recalibrating and magnifying the indicator dials, and changing the sequence of a straightening operation from before assembly to after assembly.

Since these changes have been made, we have been able to perform this operation at a satisfactory quality level as shown by the following histograms.

The ones shown in Fig. 9 give the before and after picture of chart control for the drive end of the assembly. The indicators on the balancer are calibrated in units of 0.05 ounce-inches and the charts are in the same units—hence the maximum allowable out-of-balance of ½ ounce-inches is equal to ten units. The histograms of the other end of the assembly are shown in Fig. 10.

FRONT WHEEL ALIGNMENT PROBLEMS

The second case involves front wheel alignment—the adjustment of caster and camber angles on the front suspension linkage assembly. Of course, every vehicle is final checked and, if necessary, adjusted before it leaves the final automobile assembly area. But the initial quality control should be and is exercised in the manufacture of the sub-assembly, before it gets to the final line.

The front cover picture of this issue shows the linkage assembly in place in the setting fixture. The control chart appears in the background.

Caster angle is adjusted by turning the lower bushing to the right or left until the pointer on the indicator

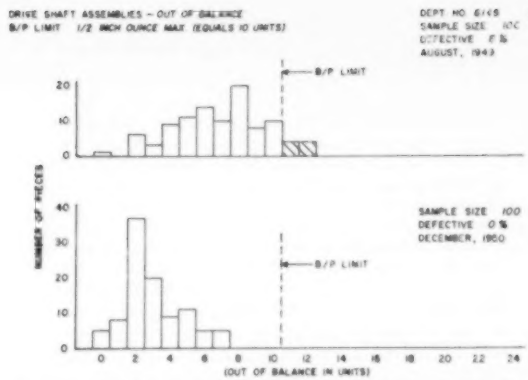

Figure 9—**Before and After Histograms of the Drive End.**

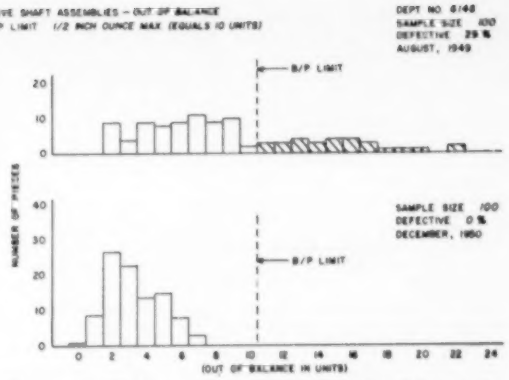

Figure 10—**Histograms of the Axle End of a Drive Shaft.**

reads within specified tolerance. The camber angle is set within indicated tolerance by turning the eccentric upper bushing, thus moving the upper end of the support inward or outward as needed.

Before SQC was applied, the inspector would spot-check individual assemblies with his gage, all of them having been set earlier by production operators. If he found any defectives, he would notify the production foreman who had his men calibrate their gages to the setting master. Then they would recheck and reset the defectives.

Figure 11 gives a before and after picture of 100 sample pieces checked for caster and camber. In October 1949, shown in the upper half of the figure, 17 percent of the assemblies sampled were out of setting tolerance on left-hand caster and 19 percent out of tolerance on left-hand camber. Right-hand settings showed a similar situation. The receiving automobile assembly plants were giving this particular supplying plant a hard time, as you might guess, because the incoming quality was so very poor. And their complaints were certainly justified. The effort of the supplying plant to remedy the situation is reflected in the distributions which appear in the lower half of the figure. Note that there are no tail ends out of tolerance. Corrections

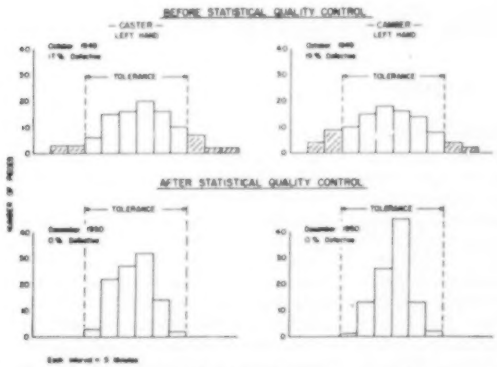

Figure 11—**Before and After Histograms of the Caster and Camber**

were not accomplished overnight; it took a lot of hard work and excellent cooperation on the part of all concerned.

The first step was to install control charts and gather preliminary data from the operation. These preliminary data revealed that the installed equipment was not suitable for setting the assemblies to the limits required by blueprint specifications. This information was presented to management, and they assigned to engineering the task of re-designing the setting fixtures.

At the same time, the production people attended several quality control sessions which presented to them the fundamentals of chart technique. This included average and range control limits, dispersion, out-of-control conditions, sigma values, chance causes, the normal curve, and so on. As a result of increased understanding on the part of the production job setters, we soon noticed an appreciable tendency toward better control. This was caused by the operators working closer to the blueprint mean and at the same time decreasing the variability.

Experiments conducted by the quality control analyst also revealed that a great deal of variation existed between setting fixtures. A test was conducted by setting the inspection gage and the three production setting fixtures to zero-zero with the master linkage assembly. Next, several assemblies chosen at random were set zero-zero in the inspection gage and then inserted in each of the production setting fixtures. Theoretically, each assembly should have read zero-zero on each fixture. By actual test, however, the variation between setting fixtures was found to be as much as 26 min.; since the total print limit is 30 min., this was obviously a very unsatisfactory condition.

To correct the condition, every setting fixture was completely overhauled by the tool room, and all worn parts were replaced with new ones. This substantially reduced the gaging error. However, some error still existed, most of it due to the inherent flexibility of the linkage assemblies themselves. This fact was brought to the attention of production supervision, and it was suggested to them that they endeavor to set the assemblies to one-third of the blueprint specifications in order to compensate for the gaging error and the flexibility of the assemblies. They agreed to do this; accordingly, the

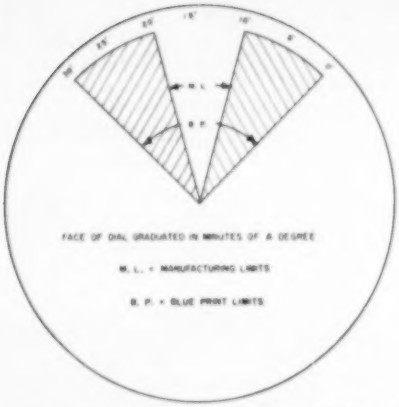

Figure 12—Dial Indicator Face After Modification

gage department colored the faces on the dial indicators as shown in Fig. 12. A further improvement in quality level was immediately noted.

The average percentage of rejects kept dropping steadily over the months, and when the new, redesigned gages and setting fixtures were received, it dropped almost to zero. This assembly is no longer a problem.

Summarizing, the following specific things were accomplished:

1. Improved quality level
2. Virtual elimination of final assembly plant complaints
3. Increase in production due to elimination of confusion and reduction in number of assemblies requiring resetting
4. Improved worker morale

The job is currently controlled by a five-piece sample from each setting fixture every two hours, a nominal effort which proves completely adequate to all concerned. The "out-of-control" red hand and "in-control" green ball are used, as in the previous case, to keep the shop posted on quality performance.

CONCLUSION

In closing, I want to make a few observations about the entire quality program, whether it be in a small firm or a large one.

It is trite, but true, that the degree of quality attained depends largely on attitudes, and particularly on those of the hourly workers. (Specifically, I mean the kind of quality which has to do with adherence to design.) Industry is so very often guilty of saying something like this without making even the least effort to square up to the problem. We generally speak of the basic desire of people to do a good job, and then trust that a kindly providence will so govern the shop as to give this desire free opportunity for satisfaction.

But in actual fact, it is up to management to provide both the means and the stimulant for quality workmanship. The top end of the organization must be peopled with men who demand quality, who are scrupulous in their decisions when quality is a factor, who are prepared to invest in quality equipment, and who put their faith in and support the full use of sound quality control techniques. Management must practice the quality ideals it preaches, and I think this is a factor of prime importance in bringing about truly effective control of quality.

We have been very fortunate in this regard at the Ford Motor Company. While our program is still a comparative fledgling, the successes we have enjoyed up to this point result mainly from the aggressive stand taken by our top management in the area of quality. Not only has SQC been firmly established as a basic, company-wide manufacturing policy, but the responsibility for quality has been brought home repeatedly to every employee, whatever his position may be.

This is a must. None of the things discussed here could be much more than attractive theories if we neglected the fact that SQC is just one means, and of course a vital one, to the end of building quality into the product. It must be accompanied by a spirited attack of the problems it reveals, if its contribution is to be fully enjoyed and if the product is to emerge a better one for its application.

Quality Control An Enigma - - - ?

WILLIAM K. WOOD*

Brunner Manufacturing Company

HAVE you, as the area quality control man in your plant, had the experience I've had of being told that you were no more efficient than the fireman who arrived at the scene long after the fire was out? Have you also been told, like me, that you make a lot of pencil marks on charts and graphs just so you can show up something that everyone already knows about? If you have, you will agree with me that being told those things puts you on the spot as far as finding the right answers to justify Quality Control is concerned. However, if you're going to make your quality control program prove itself, you have to find the right answers somehow—isn't that so?

For instance, experience has shown me that the right answers to questions about a machine performance study are answers given in terms of the machine-tooling and equipment rather than in terms of the curve of distribution. The important thing to consider in this situation, the way I see it, is whether or not the production and engineering people have had the same training in practical statistics that we've had. Nine times out of ten they haven't. Usually they only have time to specialize in their own particular fields of work. Therefore, interpreting the information recorded on our charts, so that pro-

*Assisted by Norman Nathan, Ph.D., Assistant Professor of English, Utica College of Syracuse University.

duction and engineering people can readily visualize it and understand what it means, would be to speak in terms of such things as machine down-time, machine set-up time, the cost of cutters, the relationship of a gauge to the machine fixture, the inherent properties of the work-piece material, and the capabilities of the machine itself.

However, just mentioning machine down-time or the cost of cutters is, of course, not the whole story. To be able to tell "how much"—that's the basic explanation of quality control. Tell production and engineering people how much they can expect machine down-time, the cost of cutters, or the sequence of operations to affect their normal operating costs. Let me tell you how experience has taught me to say "how much".

1. *Inspection.* . . . In order that your activities will not be confused with those of inspection, make it clear that inspection is a sorting procedure. Explain that inspection, as commonly known, only sorts good pieces of work from bad pieces of work with no attempt made to determine "how good" or "how bad" the work is. Point out that as far as inspection is concerned, there is no measuring of each individual piece of work to find out where it falls within the given tolerance, and emphasize the fact that inspection neither adds nor subtracts anything from the pieces of work—the pieces of work are no better or no worse than they were before they were inspected. Then follow up by saying that although inspection has a place in industry, it is no longer thought to be as important, as effective, as economical, or as complete as the method of control which you use.

2. *Gathering data.* . . . It may take a while to explain fully your activities of gathering data, but if you can get the idea across that most of your information will be used to indicate how many good pieces of work can be expected throughout the process, you have covered the first hurdle. One way you can start selling this idea is by using the word "information" instead of "data". In addition, be realistic about the fact that when you measure pieces of work on the production floor, you are, in a sense, inspecting the work. However, point out that you are measuring each individual piece of work you handle to find out where it actually is in relation to the mean of a given tolerance. Instead of only being able to say that a piece of work is either "in" or "out", you have the advantage of being able to say whether the work is at the mean of the given tolerance, at a certain point in the high side, or at a certain point in the low side. That's important because you can show the machine tool-setter in which direction, and how much, to move the set-up of his machine in order to keep the largest percentage of pieces within his tolerance. Explain, also, that you can show the amount of variability caused in a machining operation when a machine fixture and a gauge do not locate the same work-piece the same way. Explain further, that you can show the amount of variation to be expected in a machining operation due to inherent physical characteristics of the work-piece. Also, point out that your information will show how much inherent variation to expect in a given machine as it performs its cutting, grinding, or drilling operation.

3. *Sigma*, or *Standard Deviation.* . . . In practical application, you wish to show whether or not an operation is exceeding its tolerance. Emphasize the fact that if the standard deviation for a given operation is too large, the operation will consistently produce pieces of work outside the tolerance until corrective action is taken. If the production and engineering people decide that the cost of re-designing the equipment, changing the cutting tools, repairing the machine, re-processing the work-piece, or some other action would not be justified, specify what the necessary tolerance limits should be for the operation as it runs under the present conditions.

4. *Average.* . . . The thing to point out here seems to be the fact that an average measurement of a number of work-pieces as they are produced —at least five—will show at what point in a given tolerance a given machine is cutting the work. It has been my observation that quite a few machine tool-setters measure only a piece or two of work when setting up or adjusting a cut on a machine. Diplomatically point out, if you observe this, that it is good practice, but that you know a method of measuring which will give a clearer picture of what the machine is actually producing. Suggest that measuring five work-pieces and setting to their average measurement will give the tool-setter a precision set-up for keeping the greatest possible percentage of work-pieces within his given tolerance. Work with him a few minutes as he measures the pieces. Plot the measurements on your chart, explaining the idea as you go along, and give him the resulting average measurement. Point out that it isn't always necessary to set a machine-cut in the high side of the tolerance. Show the tool-setter how he can get the benefit of using the full tolerance and still keep the greatest possible percentage of work-pieces within his tolerance. Explain how he can quickly verify the form of tool as being correct or off-form by taking an average measurement of the pieces of work as they are produced, rather than taking the cutting tool off the machine and going to the tool room to check it on the comparator. Explain how he can level both sides of a double fixture by taking an average measurement of the work-pieces as they are produced, instead of shutting down and measuring the fixture with a special gauging set-up. Explain how he can get a better idea of the "feel" of the loading and clamping of different operators by taking an average measurement of the work-pieces instead of using the hit and miss method of trying to set "somewhere near right".

5. *Range.* . . . Probably most readily understood if you explain it as the dimensional distance between the highest and lowest work-piece of the group of pieces you measured. You could say, in a discussion involving range, that such things as dull cutters, a loose machine table, too much whip in an arbor, uneven rhythm in loading a fixture, and the softness or hardness of the material being cut would cause the double distributions and flyers which you show on your chart. Your purpose, again, is not to criticize but to show at what point in a machining operation, or process, an investigation will do the most good. Remember, you are furnishing a method of operation and process analysis for production and engineering people which is a little more adequate and a little more realistic than most other methods.

6. *Control lines.* . . . Make doubly sure that everyone understands that control lines in a machining tolerance are put in there to control the *average* measurement of a group of work-pieces—not *single* measurements of individual work-pieces. It is important for everyone to understand this so that there can be no basis for supposing that control lines

prevent operating to the total tolerance limits. Use practical examples from your charts to supplement your explanations of how control lines are established in a given tolerance. When everyone understands what is being controlled by control lines, point out that control lines are indicators, or signals, for investigation. For example, when the average measurement of a group of work-pieces exceeds a control line in a given tolerance, point out that immediate investigation will prevent excess cutter grinding costs, further cutting of work-pieces which may be defective, or further use of equipment which may be defective. Point out that by using control lines, production and engineering people can investigate and prevent trouble before it actually happens. Further, explain that they can predict how much time, money, and effort will be saved or expended before they initiate any corrective action.

7. *Distribution.* . . . In talking about distributions, you will no doubt refer repeatedly to the standard deviation, the average, and the range. Remembering that giving the right answers about quality control requires practical explanations, try keeping your explanation in terms of percentages. For example, if your information shows a given machining operation to be consistently cutting the work-pieces in too wide a distribution and that the average of the distribution is at about the same point of measurement as the mean of the tolerance, report the percentage of pieces of work falling outside of the tolerance, and emphasize the fact that this percentage of pieces will continue to be cut outside the tolerance until some corrective action is taken. By speaking this way, you have made it clear that as long as the given operation runs without further correction, the same number of pieces per hundred will continue to be cut outside the tolerance. Therefore, in terms of dollars and cents, it becomes evident that if the sub-standard work-pieces, coming from the operation are sent ahead, they are going to increase the cost of further processing by affecting the rates and standards of subsequent operations, by causing excessive burring and filing in subsequent operations, by causing excessive tool wear in subsequent operations, and by causing excessive filing and fitting in the assembling operations. And, of course, to specify how much the cost of subsequent operations will be increased, you need only to refer to your percentage figure of sub-standard work being produced by the given operation.

The Statistics in a Gear-Test Program*

B. B. DAY **F. R. DEL PRIORE**

U. S. Naval Engineering Experiment Station, Annapolis, Maryland

GENERAL

For the most effective solutions of research and development problems certain tools from the large available statistical kit are especially useful. In the initial stage of a test program statistical planning must be done to insure valid results. Only by careful building into the test structure the factors which are of interest, can the analysis of data yield pertinent information on these factors. Efficient methods of analysis are also available for the subsequent work of summarizing the experimental data after they have been obtained.

Variability is generally recognized as an inherent characteristic of all experimentation. Hence a yardstick must be provided to measure the unavoidable variation in the observational data called the experimental error. It is only by taking this inherent variation into account that differences between processes, alloys, temperatures, etc. can be judged sufficiently large for significance. Therefore, the planning must be done prior to the actual running of the test to assure an estimate of the experimental error. By statistical planning costs can be substantially reduced over those of the usual one-at-a-time method. In addition, maximum information on more points of interest will be possible. R. A. Fisher, who introduced the philosophy of statistical planning in his book "Design of Experiments" [1] states,

> "If the investigator . . . . confines his attention to any single factor, we may infer either that he is the unfortunate victim of a doctrinaire theory as to how experimentation should proceed, or that the time, material, or equipment at his disposal are too limited to allow him to give attention to more than one narrow aspect of his problem."

As you are probably aware, experimental design is a well-developed branch of statistics, wherein a large number of "designs" appropriate for a wide range of experimental conditions have been developed on firm mathematical bases.[2] Summarizing the data from these designs usually follows the well-known analysis of variance technique. In fact, Fisher's development of this procedure preceded his original work on design and became the basis for it.

The present article describes an example of statistical planning and analysis on a problem in noise.

THE PROBLEM

Due to the increase in efficiency of underwater sound detection devices, the Navy is interested in developing a quiet power transmission. The Accoustics Branch of the Wave Mechanics Laboratory, U. S. Naval Engineering Experiment Station, is studying noise characteristics of conventional and unconventional reduc-

* The opinions and assertions in this paper are the authors' and are not to be construed as official or reflecting the view of the Navy Department or the Naval Service at large. The paper was presented at the Middle Atlantic Regional Conference, American Society for Quality Control, New York, March 28, 1952.

tion gear designs as one phase of this problem. The test equipment is shown schematically in Fig. 1; the standard gear and lubricant (2190T) used, as well as other technical details, such as gear description, etc., are reported in reference (3). The long-range program is concerned with gear material, geometry, finish, etc.

The possible extraneous factors present in this study, such as lubrication, operating conditions, method of measurements, etc., are so numerous that it was advisable to conduct a preliminary study to determine optimum operating conditions of test. The objective was to find the optimum lubricating conditions as regards gear noise output. Specifically, the purpose was to determine the significance of input lubricant temperature, rate of flow, and the angle of impingement under various conditions of speed and load as related to noise.

This article reports the part that statistics played in this preliminary study. While provision was made to study nozzle design, position of measurements to be taken and the type of noise measured, these are not discussed here.

THE PLAN

Discussions between the engineers and statisticians indicated the following to be pertinent points in selecting a statistical plan:

a. The most important factor to be studied was the angle of impingement or direction of lubricant application. Four different directions were available for test. Temperature and flow volume were not as important. Speed and load were secondary. Two or three different temperature, flow, speed, and load levels were felt sufficient for this phase.

b. The technical staff stated that the factors of load, temperature and volume reacted independently of each other on noise output. No information was available on the interaction effect of angle with the other factors, while it was felt that speed might react jointly with the other factors.

c. During any eight-hour test day it would be prohibitive to change input oil temperature since this would take about three hours. The technique of changing loads would require approximately an hour, while it would take about 15 minutes to change flow volume. Speed and angle of impingement could be changed very quickly. With no changes in temperature, load, or volume, eight runs could be easily made in one working day.

The statistical plan that seemed to fit the situation was a 3x3 Latin square split-plot design with these agreed set of conditions:

(1) Load:	25%	100%	125%
(2) Temperature:	90°	120°	160°
(3) Volume:	½ gpm	1 gpm	2 gpm
(4) Speed: 300 rpm and 1200 rpm			
(5) Angle: Four directions, inmesh and tangent each at top and bottom			

These conditions gave a total number of possible combinations 3x3x3x2x4—216. However, the number of combinations actually tested was materially reduced by statistical planning based on the engineers' past experience with the factors under test. The three factors, load, temperature and volume, were studied with the Latin square plan. This design has general applicability when the factors react independently of each other and all have the same number of levels in the test. A minimum of three factors are necessary. As stated in *b* above, the factors of load, temperature and volume fulfilled these requirements.

The plan may be set up as a square with one factor the row headings, one the column headings and the third within the cells, with the restriction that the levels of the factor within the table each occurs once and only once in every row and column. Figure 2 shows the randomized Latin square scheme used. Here volume is the column headings, load the row headings, and the temperature is within the table. Reading from this structural plan, the following load-volume-temperature combinations were tested:

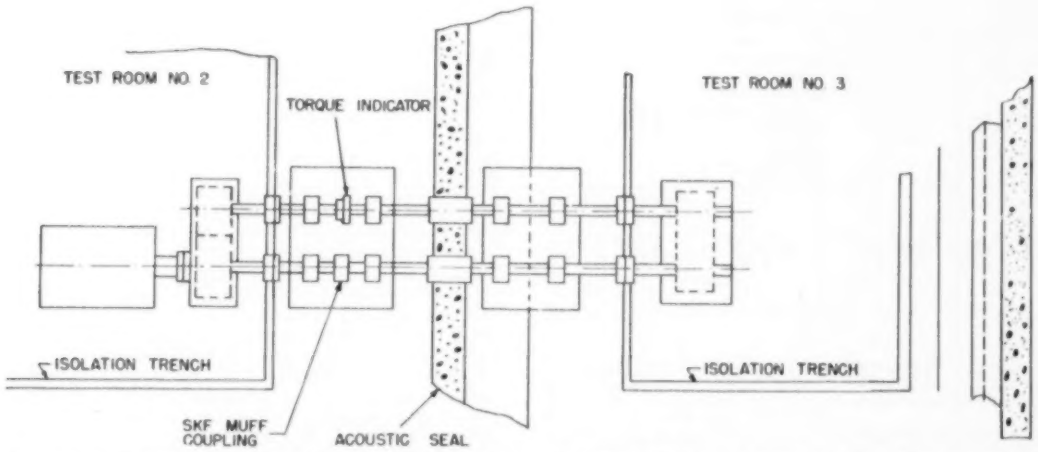

Figure 1—**Test Arrangement Used for Investigations of Acoustical Characteristics of Gears and Gear Materials (Plan View).**

TABLE 1. Test Data in Decibels from Preliminary Gear-Noise Study
(3x3 Latin square split-plot design)

Load percent	Speed rpm	Volume	Direction†					Direction†					Direction†					TOTALS
			TB	IT	IB	TT	Total	TB	IT	IB	TT	Total	TB	IT	IB	TT	Total	
		½ gpm			120°			1 gpm *			90°		2 gpm			160°		
25	300		92.7	95.9	92.7	92.2	701.0	91.3	87.7	93.6	92.9	659.6	86.9	90.7	92.1	90.6	702.4	2063.0
	1200		81.4	79.2	85.5	81.4		68.0	77.7	76.2	72.2		78.2	97.9	80.2	85.8		
					90°					160°					120°			
100	300		94.2*	88.6	89.8	89.8*	685.6	89.7	87.8	90.4	90.4	695.2	91.9	85.4	85.7	82.6	675.8	2056.6
	1200		80.2*	83.7	83.9	75.4*		86.0	86.6	79.3	85.0		84.8	79.5	86.9	79.0		
					160°					120°					90°			
125	300		88.7	92.1	91.7	93.4	726.6	90.3	90.3	90.4	89.7	700.5	88.4	86.3	88.3	88.6	671.0	2098.1
	1200		94.2	91.1	89.2	86.2		86.7	83.5	86.6	83.0		75.8	71.2	87.9	84.5		
	TOTALS						2113.2					2055.3					2049.2	6217.7
		Temperature																
		90°						120°					160°					
		2016.2						2077.3					2124.2					

* Missing Data Supplied
† TB, IB = tangent and inmesh bottom; TT, IT = tangent and inmesh top

Combinations in Test

Load %	Volume gal/min	Temperature deg F
25	½	120
25	1	90
25	2	160
100	½	90
100	1	160
100	2	120
125	½	160
125	1	120
125	2	90

One combination was to be tested each day, or a total of nine days testing time. Therefore, the use of the Latin square not only cut testing time from 27 days to nine days, by reducing the number of combinations to test, but also avoided waiting for temperature equilibrium to be reached, etc.

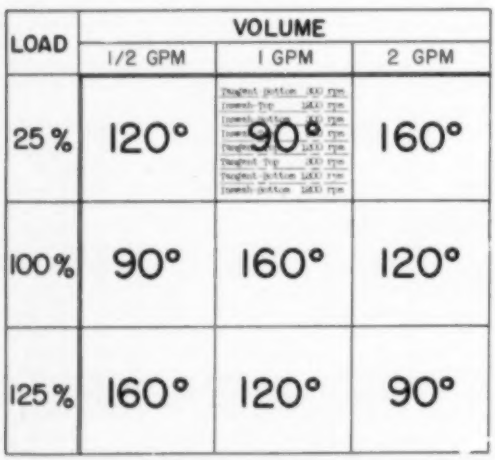

Figure 2—**3x3 Split-Plot Latin Square for Preliminary Gear Test**

The eight possible speed-direction set-ups were tested at each of the above nine load-volume-temperature conditions, a total of 72 individual readings for one replication. This introduced the "split-plot" element. Hence the overall plan is called a 3x3 Latin square split-plot design. The order of testing for the nine load-volume-temperature combinations was randomized as well as the eight speed-direction set-ups within each of the nine. This arrangement allowed for the estimates of two kinds of error, the long-time or day-to-day and the short-time or within-the-day. The random order of testing was done as insurance against biased data and to yield valid estimates of the experimental error. The first day's condition was randomly selected to be load 25%; volum 1 gpm; temperature 90° F. The randomized order of testing the eight speed-direction conditions made the first day is also shown in Fig. 2.

The original plan called for repeating 72 runs. However, this was not done due to time limitations. As the results indicated, the second replication was not really needed.

THE ANALYSIS

The data were analyzed by the analysis of variance technique. Analysis of variance is a statistical technique for evaluating the effect of the controlled factors on the results. In a properly designed test, the total variation is partitioned into the various sums assignable to the factors under control, their joint effects, and a remainder known as the error term. The average effects of each of these furnish a basis of comparison from which probability values can be found. These values are the probabilities that the differences observed during the test are merely sampling fluctuations. Thus, the lower the probability, the more unlikely are the differences due to random fluctuations. A probability as low as 0.05 is usually considered as meaning that the factor is significant, hence real in its effect.

The data are presented in Table 1. These are from runs made with the new designed nozzle. The data are

TABLE 2. Speed by Direction Totals (decibels)
(Total of 9 observations—loads, volumes and temperatures)

Speed rpm	Direction				All directions
	TB	IT	IB	TT	
300	814.1	804.8	814.7	810.2	3243.8
1200	735.3	750.4	755.7	732.5	2973.9
Both speeds	1549.4	1555.2	1570.4	1542.7	6217.7

TABLE 3. Speed by Load Totals (decibels)
(Total of 12 observations—temperatures, volumes and directions)

Speed rpm	Load			All loads
	25%	100%	125%	
300	1099.3	1066.3	1078.2	3243.8
1200	963.7	990.3	1019.9	2973.9
Both speeds	2063.0	2056.6	2098.1	6217.7

in decibels referred to a base level of 10^{-6} in/sec measured at the tooth contact frequency on the base of the gear housing. Four of the 72 speed-direction runs were not made. Standard "missing plot" technique was used[4] to estimate values which would minimize the effect of these missing observations.

The total sum of the squares of the deviations of the individual observations from the mean (average) of all is partitioned into the various sums assignable to the factors in the test, to their joint effects, and to the inherent error or variability of the test itself. The calculations are shown in the appendix. The size of the ratio of the mean square of a factor (that is, its sum of squares divided by the corresponding degrees of freedom) to its error, indicates whether or not changes in that factor have a significant influence on the measured characteristic. The larger this ratio, the stronger is the evidence that changes in the factor under study do have an effect, and the smaller is the chance of such a statement being wrong. Tables are available in most standard texts linking the size of ratios with the corresponding probabilities for various degrees of freedom.[4]

The analysis of variance of a split-plot is divided into two parts, each yielding an experimental error and tests of significance of the factors therein. The main part in this experiment is the analysis of the 3x3 Latin square involving volume, load and temperature (upper portion of Table 4). The totals (Table 1) of the eight decibel readings within each of the nine cells are used, the procedure following that for the ordinary Latin square. The subpart is calculated from the decibel readings within each of the nine Latin square cells.

By the purposeful planning, the interaction or joint effects of speed and direction can be estimated. This is not the case for volume, load and temperature in the Latin square. From experience the engineer was able to state that these three factors would not jointly affect noise levels. Hence, this was the basis for using the Latin square design.

Table 4 is the analysis of variance summary. The first concern is the magnitude of error involved. In this case we have the two error terms. The subpart error is 15.7542 on our scale. When the day-to-day factor is included, the main part error is 8.2250. The fact that these are of the same order of magnitude implies that the daily calibration of the test equipment is entirely satisfactory, i.e., there is no day-to-day lack of stability (after calibrations). This also verifies the engineers' statement that there is no joint effect between load-volume-temperature. While there was an actual deviation from the original test plan in that the load-volume-temperature condition was changed a few times within a day, this did not occur often enough to invalidate the analysis.

As stated above, the experimental error was found to be 15.7542 in terms of the analysis of variance scale (mean square). The square root of this measure gives the familiar standard deviation. In this case it was 3.97 db. This is taken as the experimental error of the test which is the basis for estimating the uncontrolled effects on the test. Hence an average value from sample size n could fluctuate as much as $\pm 8.1/\sqrt{n}$ db in 95 out of 100 cases.

The next concern is the comparison of the measures of the factors (mean square) with the error measure (mean square). Table 4 reveals that of all the factors studied, speed, the joint effect of speed with load and of speed with temperature, and possibly volume, are important in causing variations in noise output. While the temperature measure is significantly larger than the error term, the strong interaction of temperature with speed nullifies this. The variations observed in the data assignable to the other factors were not found to be significant as compared to the errors involved. This information tells us what means to examine, what factors to disregard.

As the result of this test, it was possible to make the following definite statements:

a. The angle of impingement is not important under any of the conditions tested. Therefore this factor should

TABLE 4. The Analysis of Variance of Test Data in Decibels from Preliminary Gear-Noise Test
(3x3 Latin square split-plot design)

Source of Variation**	Degrees of Freedom (1)	Sum of Squares (2)	Mean Square (3)
Main part (3x3 Latin square)			
L	2	41.60	20.80
V	2	103.97	51.98
T	2	244.40	122.20
Error	2	16.43	8.225
Sub-part (split-plot)			
S	1	1011.75	1011.75§
D	3	23.25	7.75
SXD (1×3)	3	26.43	8.81
SXL (1×2)	2	136.68	68.34†
SXV (1×2)	2	47.81	23.90
SXT (1×2)	2	203.76	101.88¶
DXL (3×2)	6	143.89	23.98
DXV (3×2)	6	20.81	6.47
DXT (3×2)	6	146.14	24.36
Error	28*	441.12	15.7542
Total	67	2608.04	

* Decreased by four because of missing observations.
† Probability is less than .05 that the differences observed are simply due to random fluctuations.
¶ Probability is less than .01 that the differences observed are simply due to random fluctuations.
§ Probability is less than .001 that the differences observed are simply due to random fluctuations.
** L = load; V, volume; T, temperature; S, speed; D, direction; S×D, speed vs. direction; etc.

be eliminated in the long-range program. This conclusive evidence has resolved a wide disagreement.

b. Changes in the input temperature were only effective at the high speed where the gear became noisier at the higher temperature approaching the noise output at the low speed.

c. The low volume consistently produced a slightly higher noise level.

d. Load had no effect at the low speed; at high speed, the noise increased with the load.

e. The speed of the run was the greatest single influence on noise, the low speed averaging 8.1 db higher than did the high speed.

The technical staff was impressed with the statistical treatment, particularly in the saving of time and money in the running of the test and in the pertinent information which the analysis furnished. The long-range program is now in the process of being statistically planned. The success of the statistical contribution is due in a large measure to the fine cooperation of the engineers directly concerned with the project.

Acknowledgments are made to the superintendent of the Wave Mechanics Laboratory, Mr. H. C. Dalrymple, for the use of this example, and the Acoustics Branch, particularly Mr. M. G. McGraw, for assistance on the technical details.

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(3) Robbins, M. W., Jr., *Gear Spray Lubricant Noise Test*, U. S. Naval Engineering Experiment Station Report 5B066841, Annapolis, Maryland, 1951

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APPENDIX: Steps in Computing Table 4

(Refer to Table 1, the original data, and Tables 2 and 3)

1. The total sum of squares is found by squaring the individual observations, summing, and then adjusting the sum for the grand mean.

$$C = \frac{(\Sigma x)^2}{n} = \frac{(6217.7)^2}{72} = 536{,}941.57$$

2. Main Part (3x3 Latin square)

a. The total sum of squares

$$= \frac{(701.0)^2 + (659.6)^2 + \ldots + (671.0)^2}{8} - C = 406.40$$

b. Load (rows)

$$= \frac{(2063.0)^2 + (2056.6)^2 + (2098.1)^2}{24} - C = 41.60$$

c. Volume (columns)

$$= \frac{(2113.2)^2 + (2055.3)^2 + (2049.2)^2}{24} - C = 103.97$$

d. Temperature

$$= \frac{(2016.2)^2 + (2077.3)^2 + (2124.2)^2}{24} - C = 244.40$$

e. Error

$$= 406.40 - (41.60 + 103.97 + 244.40) = 16.43$$

3. Sub-Part (split-plot)

a. The total sum of squares

$$= (92.7)^2 + (95.9)^2 + (92.7)^2 + \ldots + (84.5)^2 - C = 2608.4$$

b. Speed (rows Table 2)

$$= \frac{(3243.8)^2 + (2973.9)^2}{36} - C = 1011.75$$

c. Direction (columns Table 2)

$$= \frac{(1549.4)^2 + (1555.2)^2 + (1570.4)^2 + (1542.7)^2}{18} - C = 23.25$$

d. Speed × Direction (Table 2)

$$= \frac{(814.1)^2 + (804.8)^2 + \ldots + (732.5)^2}{9} - C - a_3 - b_2 = 26.43$$

e. Speed × Load (Table 3)

$$= (1099.3)^2 + (1066.3)^2 + \ldots + (1019.9)^2 - C - a_3 - b_2 = 136.68$$

f. Sum of squares for remaining joint effects computed as in 3e.

g. Error term obtained by subtracting the sum of all the computed items from the total sum of squares.

UNIVERSITY OF CALIFORNIA SUMMER SESSIONS

This year's summer program at the Statistical Laboratory of the University of California, Berkeley, California, consists of two sessions: June 22—Aug. 1 and Aug. 3—Sept. 12. The faculty for the summer sessions will include Professor David Kendall of Magdalen College, Oxford University; Professor J. Neyman, Dr. T. A. Jeeves, and Mr. A. Shapiro of the Statistical Laboratory, University of California.

The program includes two of the usual undergraduate courses in each session. In addition, during the first session Professor Kendall will give a new course, "Stochastic Processes Associated with Population Growth and with the Theory of Queues." This course is designed to acquaint students with the probabilistic treatment of growth of populations subject to birth, death, immigration, mutation and aging.

Notice

THE 1952-53 ASQC YEARBOOK

will be available about April 1. Mailing will be made to every member who sent in a request card for the Yearbook with his membership renewal. The quantity printed was based on the number of request cards received, but a small over-supply will be available. While this lasts, members who have not previously requested a copy may secure one by writing to the office of the Executive Secretary. Be sure to indicate Section affiliation if you write in for a Yearbook.

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7th Annual ASQC Convention—TENTATIVE PROGRAM

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II.	GENERAL INTEREST *The Union Looks at Quality Control* Wm. Gomberg, Dir. Mgmt. Engrg. Dept., International Ladies' Garment Workers Union, New York, N.Y. Second Topic: To be announced.	ARMED SERVICES—SAMPLING INSPECTION *Ordinance Standard 80—Acceptance Inspection by Variables* H. M. Rosenblatt, Head, Stat. Branch, QC Div., Dept. of Navy, Bureau of Ord., Washington, D.C. *Ordnance Standard 81—Acceptance Inspection on a Moving Line* H. Weingarten, Stat. Branch, QC Div., Dept. of Navy, Bureau of Ord., Washington, D.C.	CHEMICAL INDUSTRY—PHARMACEUTICAL APPLICATIONS *Applications of SQC in the Pharmaceutical Industry* T. J. Moran, SQC Supvr., Wyeth, Inc., West Chester, Pa. *Role of a Biometrician in the Pharmaceutical Industry (Illustrated)* C. I. Bliss, Biometrician, Conn. Ag. Exp. Sta., New Haven, Conn.	AUTOMOTIVE INDUSTRY *Military Inspection Procedures of Vehicles & Parts* Paul Roche, Chief, QC, Detroit Arsenal, Centerline, Mich. *QC in an Automotive Foundry* Allen Evans, QC, Foundry Div., International Harvester, Indianapolis, Ind.
III.	QUALITY CONTROL ENGRG. AND TRAINING *Company Education on the Quality Problem* A. V. Feigenbaum, Mgr. of Programming, General Electric, Cincinnati, Ohio *Methods of Training for QC Engineers and Supervisors* Ralph Wareham, Pres., Ralph Wareham & Assoc., Chappaqua, N.Y.	ARMED SERVICES—AIRCRAFT *Practical Application of SQC in the Aircraft Industry* Phil Harr, Qual. Mgr., Fairchild Aircraft, Hagerstown, Md. Film—*Quality Control in the Aircraft Industry*	CHEMICAL INDUSTRY—PETROLEUM APPLICATIONS *The Application of Statistical Methods in Research & Development* Speaker: To be announced *Some Applications of Statistics in a Refinery* C. T. Shewell, Res. Specialist, Humble Oil & Refining, Baytown, Texas	COMPUTER APPLICATIONS IN THE METALS INDUSTRY *Application of I.B.M. Equipment to the Solution of a Metallurgical Correlation Problem* D. H. W. Allan, Proc. Div., Metallurgical Dept., The Steel Co. of Canada, Hamilton, Ontario *Application of Consolidated Computer to the Solution of a Metallurgical Correlation Problem* D. S. Leckie, QC Eng., and R. F. Cain, Asst. Supt. QC, Republic Steel, Cleveland, Ohio
IV.	ENGINEERING AND QUALITY CONTROL *Analysis of Dimensions and Tolerances* Prof. E. Buckingham, Mass. Inst of Technology, Cambridge, Mass. *Statistical QC in Relation to Engineering* Dr. J. H. Davidson, Head, Stat. Meth. Section, Electro-Mech. Div., General Electric, Schenectady, N.Y.	ARMED SERVICES—MIL-Q-5923A *Military and Industry Views of the Interpretation and Administration of MIL-Q-5923A* J. G. Schneider, Acting Chief, QC Div., Wright-Patterson AFB, Dayton, Ohio O. C. Griffith, Chief, Operations Office, QC Div., Wright-Patterson AFB, Dayton, Ohio Joseph Paul, QC Mgr., Glenn L. Martin Co., Baltimore, Md. H. Simpson, A.G.T. Div., General Electric, Cincinnati, Ohio	TEXTILE INDUSTRY *Statistics in Textiles with an Application* E. S. Rudnick, Dir. of Res., Wamsutta Mills, New Bedford, Mass. *Evenness Testing Applied to Textile QC* Panel Discussion—Members to be announced	METALS INDUSTRY *SQC in the American Brass Co.* F. G. Smith, Metallurgist, American Brass, Waterbury, Conn. *Testing Production Data for Normality* F. G. Norris, Metallurgical Eng., Wheeling Steel, Stubenville, Ohio
V.	GENERAL INTEREST *Installing a QC Program* H. T. Hallowell, Jr., Pres., Standard Pressed Steel, Jenkintown, Pa. *Management's Use of QC* C. R. Scott, Jr., Mgr., Otis Elevator, Yonkers, N.Y.	ARMED SERVICES—MIL STANDARDS *Specifications and Standards as Tools of Military Standardization—Their Development and Their Coordination with Industry* R. A. Moody and representatives, Dir., Office of Standardization, Washington, D.C.	TEXTILE INDUSTRY First Topic: To be announced. *The Consumer's Stake in Textile Quality* or, *What is the USE in Testing* Dr. J. Labarth, Jr., Senior Fellow, Mellon Inst. of Ind. Res., Univ. of Pittsburgh, Pittsburgh, Pa.	PLANT TOUR General Testing Laboratories and Manufacturing Div. of the Philadelphia Quartermaster Depot, Philadelphia, Pa.

Period	E	F	G	H
I.	RELIABILITY OF ELECTRONIC EQUIPMENT *Applications of Statistical Methods in Evaluating Performance of Electronic Equipment* G. R. Herd, Supvr. of Stat. Dept., Aeronautical Radio, Washington, D.C. *Statistical Appraisal of Workmanship in Vacuum Tube Quality* A. J. Heitner, Sylvania Elec. Prod., Emporium, Pa.	APPLICATIONS IN THE PROCESS INDUSTRIES *Attaining Uniformity in Processing Rubber Batches* P. E. Gnaedinger, Dir. of QC, Dominion Rubber, Montreal, Quebec *QC Applications in Paper Box Board Manufacturing* B. E. Sooy, Chief of QC, Gardner Board & Carton, Middletown, Ohio	PLASTICS MANUFACTURING *Process Control in a Plastics Mfg. Plant* R. C. Boyd, Head, Thermoplastics Wks. Lab., Bakelite Div., Union Carbide and Carbon, Bound Brook, N.J. *Statistics Applied to Plastics Evaluation* C. H. Adams, Plactics Div., Monsanto Chemical, Springfield, Mass.	ADVANCED EDUCATIONAL SESSIONS *General Introduction and Sampling. Variation, Variance & Ratio-Test.* E. C. Harrington, Jr., Mgr. Ind. Stat., Monsanto Chemical, Springfield, Mass.
II.	LIFE TESTING ELECTRICAL & ELECTRONIC EQPT. *A Statistical Theory of Life Testing and Some of Its Applications* Prof. Benjamin Epstein, Dept. of Math., Wayne Univ., Detroit, Mich. *How Reliable is Your Life Testing Procedure?* J. A. Davies, Supvr. of Stat. Control Methods, General Electric, Owensboro, Ky.	MATHEMATICAL STATISTICS—THEORY *Linear Programming* Prof. A. W. Tucker, Math. Dept., Princeton Univ., Princeton, N.J. *Experimental Design* Dr. Lee Crump, Head, Stat. Section, Atomic Energy Proj., Univ. of Rochester, Rochester, N.Y.	QC APPLICATIONS IN THE FOOD INDUSTRY *The Effect of the Concentration and Flavor Intensity in a Food Product on the Organoleptic Senses* D. A. Brandt and E. S. Edelman, Schenley Dist., Cincinnati, Ohio *Controlling Process in the Brewing Industry* R. I. Tenney, Pres., Wahl-Henius Institute, Chicago, Ill.	ADVANCED EDUCATIONAL SESSIONS *Sampling Variation of Averages, Student's t Test.* *Sample Size, Power of Test.* Norman Garner, Quartermaster Depot, Philadelphia, Pa. ADVANCED EDUCATIONAL SESSIONS *Design of Experiments—Introduction, Randomized Blocks, Latin Squares, etc.* *Design of Experiments—1 Factor and 2 Factor Design, Analysis of Variance.* M. A. Brumbaugh, Dir. of Stat., Bristol Laboratories, Syracuse, N.Y. D. B. DeLury., Dept. of Math. Stat., Ontario Res. Foundation, Toronto, Ontario.
III.	GAGING AND GAGE DESIGN *The Development and Functions of a Gage Laboratory* C. H. Borneman, Mfg. Eng. Serv. Dept. General Electric, Schenectady, N.Y. *The Impact of QC on Gage Design* John Harrington, DoAll Co., Des Plaines, Ill.	VENDOR RELATIONS *Who Controls the Vendor's Quality?* J. P. Worth, Chief Inspector, Electrolux, Old Greenwich, Conn. *Vendor Response to the QC Approach* C. R. Burdick, Supvr. Stat. Anal. Section, Ford Motor, Dearborn, Mich.	INSPECTION AND TRANSIT *Specialized Lighting for Inspection and Control* E. A. Lindsay, Electrical Eng., Lamp Div., General Electric, Cleveland, Ohio *Pretesting Package Products—A Vital Phase of QC* R. F. Bisbee, Mgr. QC, Westinghouse Electric, Mansfield, Ohio	ADVANCED EDUCATIONAL SESSIONS *Design of Experiments—3 and 4 Factors.* *Design of Experiments—Confounding and Fractional Replication.* M. A. Brumbaugh, Dir. of Stat., Bristol Laboratories, Syracuse, N.Y. D. B. DeLury, Dir., Dept. of Math. Stat. Ontario Res. Foundation, Toronto, Ontario
IV.	QC IN PRECISION MANUFACTURING *Loss Reduction in Precision Manufacturing* E. R. Close, Chief Inspector, Instr. Div., Bausch & Lomb Optical Co., Rochester, N.Y. *Controlling Visual Characteristics on Precision Parts* A. S. Hayes, QC Supvr., Perfect Circle Co., Hagerstown, Ind.	OPERATIONS RESEARCH *Industrial Applications of Operations Research* Dr. J. B. Lathrop, Arthur D. Little, Inc., Cambridge, Mass. *The Place of Operations Research vs. Quality Control* Dr. S. S. Wilks, Princeton Univ., Princeton, N.J. W. R. Weaver, Republic Steel, Cleveland, Ohio J. D. Lathrop, Arthur D. Little, Inc., Cambridge Mass.	INDUSTRIAL RELATIONS *Industrial Engineering and QC* A. E. Longley, Mgr. of Training, Atlas Steels, Welland, Ontario *Work Sampling* C. L. Brisley, Ind. Eng. Mgr., Wolverine Tube Div., Calumet & Hecla Copper, Detroit, Mich.	
V.	PLANT TOUR Ford Motor Company, Chester, Pa.	MATHEMATICAL STATISTICS *The Theory of Sampling* W. E. Deming, Prof. of Statistics, N.Y. Univ. *Chi-Square Tests of Independence* Prof. A. J. Duncan, Assoc. Prof. of Stat., Johns Hopkins Univ., Baltimore, Md.	PLANT TOUR The Budd Company, Philadelphia, Pa.	ADVANCED EDUCATIONAL SESSIONS *Correlation & Regression—Linear.* *Correlation & Regression—Multiple & Curvilinear.* B. B. Day, Principal Stat., U. S. Naval Eng. Exp. Sta., Annapolis, Md.

7th Annual ASQC Convention

SCHEDULE OF COMMITTEE MEETINGS

WEDNESDAY, May 27
4:35 p.m. Convention Hall
Annual Meeting of the Society

THURSDAY, May 28
4:35 p.m. Convention Hall
Chemical Division—Annual Meeting
9:30 p.m. Hotel Benjamin Franklin
Chairmen of Society General Committees
Regional Conferences Committee
Editorial Board

FRIDAY, May 29
4:35 p.m. Convention Hall
Textile Division—Annual Meeting
5:00 p.m. Hotel Benjamin Franklin
Operations Research Committee
8:30 p.m. Hotel Benjamin Franklin
Committee on Technical Societies Relations
Examining Committee
Professional Ethics Committee
Directors for 1953-54

SATURDAY, May 30
8:00 a.m. Hotel Benjamin Franklin
Auditing Committee
Shewhart Medal Committee
Brumbaugh Award Committee
Aircraft Technical Committee
Electronics Technical Committee
Metals Technical Committee
Membership Committee
10:00 a.m. Hotel Benjamin Franklin
General Convention Committee
Section Affairs Committee
Historical Committee
Automotive Technical Committee
Standards Committee
Program and Speakers Committee
Education and Training Committee
2:00 p.m. Hotel Benjamin Franklin
Board of Directors (1952-53) Meeting
6:30 p.m. Hotel Benjamin Franklin
Board of Directors (1952-53) Banquet

PREVIEW OF EXHIBITS

Booths 9-10

MARCHANT CALCULATORS

Marchant will exhibit three top models in its line of fully automatic and semi-automatic electric calculators. The FIGUREMASTER has automatic "push-button" multiplication, automatic division line-up and other features designed for heavy volume figurework. The low-cost FIGUREMATIC features "push-button" multiplication and a new dial-set clear-return control. The third is a *livetab* model unusually well adapted to correlation problems.

Representatives of the company's Philadelphia and surrounding offices will give demonstrations of the use of Marchant calculators. Several additional machines will be available for visitors to operate in solving QC or other mathematical problems.

Of particular interest to QC engineers will be demonstrations of such figurework as standard deviation and interpolation—for which Marchant is ideally suited.

H. J. Koberle, Marchant's Philadelphia Agency Manager, will be in charge of the booth.

Booth 13

ELLIOTT SERVICE COMPANY

Featured at the Elliott Service Company's display will be the following management services:

1. Colorful "Quality-Cost" Displays for weekly departmental posting in large and small manufacturing plants to help stimulate employee quality consciousness.
2. A complete bulletin board display service to reinforce managements's daily contact with employees. This display features colorful, weekly poster presentations of those subjects requiring plant-wide cooperation such as Quality Workmanship, Waste Reduction and Accident Prevention. Special posters are available for the textile industry. Bulletin display boards are furnished in silver-gray, hammered-tone, or green baked-enamel finish. A chrome-finished 3-panel display fixture is also available for departmental publicity.
3. Samples of "MANAGEMENT INFORMATION for Foremen and Supervisors," a weekly bulletin covering Quality Maintenance, Waste and Cost Reduction, Training, Human Relations, Safety. Also samples of Supervisory Training Outlines and booklets on similar subjects.
4. Samples of Elliott's Suggestion System Service, including weekly THINK-Stimulator displays, suggestion panel boxes and monthly Suggestion Bulletins.

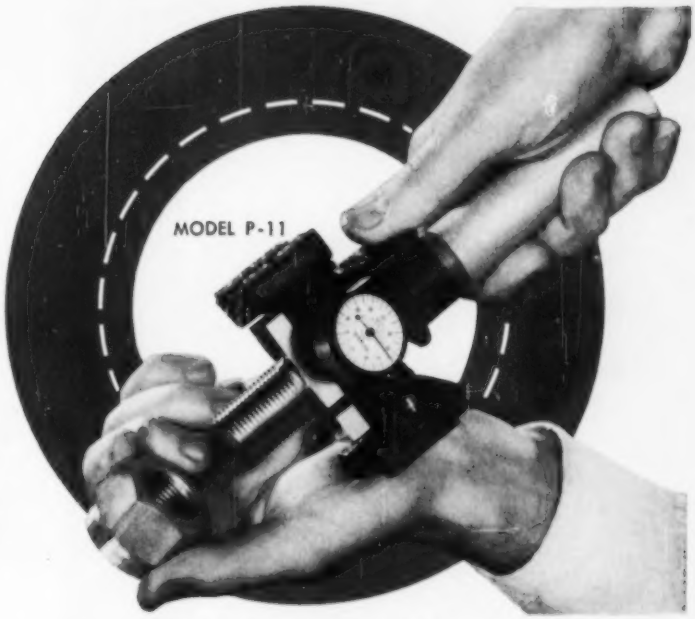
Booth 20

THE VAN KEUREN CO.

The Van Keuren Company of Watertown, Massachusetts, manufacturers of precision measuring equipment for 33 years, will feature in their exhibit a new monochromatic light, fused-quartz optical flats (accurate for flatness to 0.000001 in., in sizes from 1 to 10 in. in diameter) and a new line of chrome carbide, taper-insert plug gages.

The 0—3 in. light wave micrometer, which makes direct measurements to 0.000010 in., will also be shown. A complete line of gage blocks, cylindrical standards, measuring rolls, root diameter wires, taper-insert plug gages, thread measuring wires and micrometer lapping and testing equipment will be displayed.

BRYANT GAGE FOR INTERNAL THREADS



The P-11 is a portable comparator gage. Variation from basic size of pitch diameter, form and lead are shown in a single reading on the dial indicator accurate to .0005". Interchangeable pairs of segments inspect all classes of threads in a range from 5/16" to 5" diameter.

The gage segments work on the principle of an expanding master plug. A thumb lever collapses one segment so that the part can be loaded. When the lever is released the segments engage the thread. The movement of one segment registers on a precision dial indicator which shows the accumulated amount of variation from basic size. The segments are made to the same tolerances in P. D., form and lead as a class "W" master. The segments are attached by four screws. Periodically the segments are checked to a master ring gage and the "0" setting of the indicator is adjusted accordingly. Worn segments may be returned to the factory to be reground. Dirt or cutting oil cannot affect the working parts of the gage as there are no slides or pivots. The indicator may be turned on the axis of the stem to keep the dial visible. This gage weighs only 14 oz. without the segments.

This gage is designed for use at the inspection bench or in the shop. It is used for quality control since complete control of the thread cutting process is possible. The indicator reading of variation from basic size tells exactly where within limits the work is running. For this reason also, the gage is used for checking tool wear in production jobs.

Please send descriptive literature covering the P-11 gage and other Bryant gages.

Bench type gages for external or internal threads are available, with or without squareness-of-face attachment.

BRYANT

CHUCKING GRINDER CO.

Springfield, Vermont, U. S. A.

MAIL THE COUPON TODAY!

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Please send me illustrated folders giving full information on the Bryant Portable and Bench Thread Gages.

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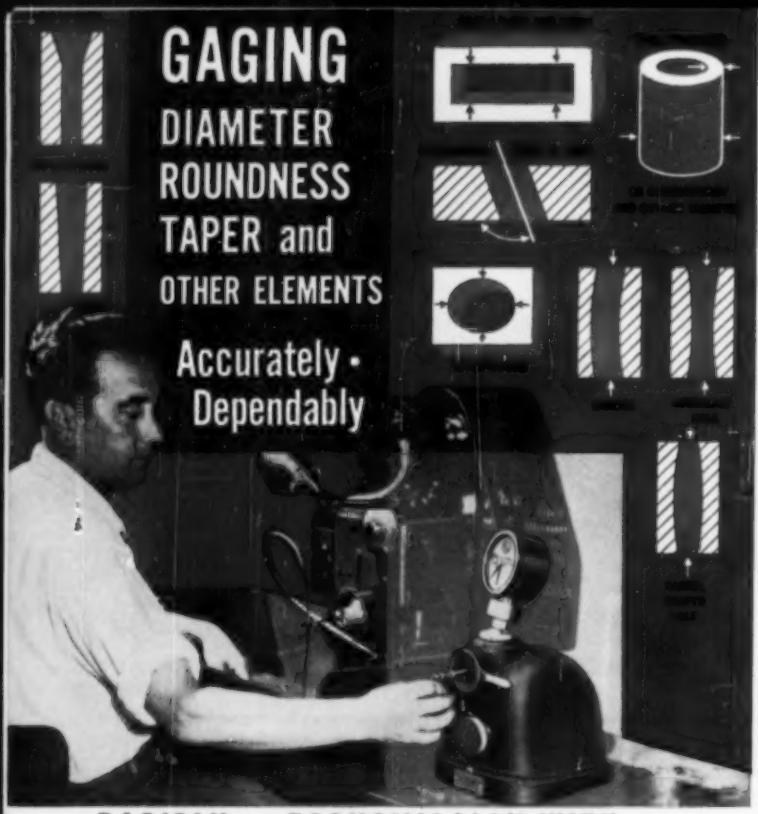
COMPANY_____

STREET_____

CITY_____ STATE_____



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Extremely versatile and accurate, the Pratt & Whitney Air-O-Limit Comparator is small, compact and simple . . . with no moving parts but the gaging indicator. Gaging is accomplished by measuring the back pressure created when the part being tested partially limits the flow of air through a pair of nozzles. Regular industrial lines provide a satisfactory compressed air source.

A wide range of internal and external sizes and shapes can be tested rapidly and dependably to an extremely high degree of accuracy.

Pratt & Whitney Air-O-Limit Gages can reduce inspection costs and improve quality control in your plant. For complete information on this faster, better gaging method, send today for Bulletin No. 524-1. Write on your Company letterhead to the P&W Branch Office nearest you—or direct to West Hartford.

Bulletin 524-1

PRATT & WHITNEY
DIVISION NILES-BEMENT-POND COMPANY
WEST HARTFORD 1, CONNECTICUT, U. S. A.

First Choice P&W *for Accuracy*

CUTTING TOOLS • GAGES • MACHINE TOOLS

Other products to be on exhibition are, steel and tungsten carbide, wiretype plug gages, chromium plated wires, steel optical flats and calibrated steel balls.

Booths 21-22

AMERICAN CYSTOSCOPE MAKERS

American Cystoscope Makers, Inc. will display industrial inspection telescopes (borescopes). These instruments are used for the visual inspection of relatively inaccessible surfaces. A new design telescope for the examination of airplane cylinder-type engines will be shown. This device has a special electrical circuit for the illumination of the instrument lamp which eliminates the possibility of ignition of any residual explosive gases upon introduction.

Booth 23

CLEVELAND INSTRUMENT

The Cleveland Instrument Company (formerly Graham-Mintel Instrument Company) will exhibit the MICRO-AC electronic microcomparator, the INDI-AC electronic height gage, and the PAR-AC electronic production gage with height gage accessories. The display will also include electronic gaging equipment operating with a pen recorder. Partially disassembled amplifiers and gage heads will be available for examination.

Booths 24, 25 & 26

MOORE PRODUCTS

Pneumatic comparator gages will be shown in working demonstrations at the exhibit of Moore Products Company, Philadelphia, Pa. Included will be gages for measuring internal diameters, outside diameters, wall thickness, and combinations of dimensions. Particular emphasis will be placed on the use of the equipment in quality control systems in which the operators use the gages at honing or grinding machines.

A demonstration also will be made of Moore equipment for automatic gaging in which jo-blocks are used instead of work pieces, to show the accuracy and repeatability of the equipment.

Booth 28

TAFT-PEIRCE MANUFACTURING

The exhibit of The Taft-Peirce Manufacturing Company will be devoted exclusively to quality control equipment with particular emphasis on instrument gages. Among the items shown will be a selection of plain and thread gages of the ring, plug, and snap variety, including some manufactured from tungsten carbide and norbide.

The feature of the exhibit will be a display of Taft-Peirce compAIRator air gages. In addition to a group of standard air snaps, air plugs, and air rings, with and without hose extensions, an air-electric device will be operating continuously to illustrate the unique translation of no-contact air gaging to flashing light indication. A 0.058 in. air

plug will show how air gaging can be applied successfully to the checking of very small diameters.

The Taft-Peirce "Roto-check," a novel power-operated, thread gaging unit, will be of interest to those anxious to accomplish more rapid inspection of threaded parts.

The booth will be manned by several gage engineers who will be glad to discuss specific gaging problems with visitors.

Booth 29

COSA CORPORATION

Sigma multi-dimensional inspection equipment, mechanical and electrical comparators, will be exhibited by the Cosa Corporation of New York.

Featured demonstration will be the use of a basic, standard, multi-dimensional inspection machine with different tool set-ups for 100 percent production inspection on a variety of parts. With this standard equipment and suitable tooling, any number of dimensions can be checked simultaneously. Turbine or compressor blades are checked at as many as 30 points at the same time.

Also in operation will be the Vertical Mechanical Comparator; the Turret Mechanical Comparator having one measuring head and a revolving turret with work-holding fixtures for checking up to ten dimensions; and for extremely precise inspection, the Electrical Comparator with scale magnifications ranging from 10,000 to 50,000 times.

Booths 30-31

SHEFFIELD CORPORATION

A complete line of instrument gaging equipment will be exhibited by The Sheffield Corporation of Dayton, Ohio. Among the new products will be an Airetest indicating head for very precise, surface-plate measurements and hole location. Also, various applications of Plunjets for gaging, for fixtures, and for machine control will be demonstrated.

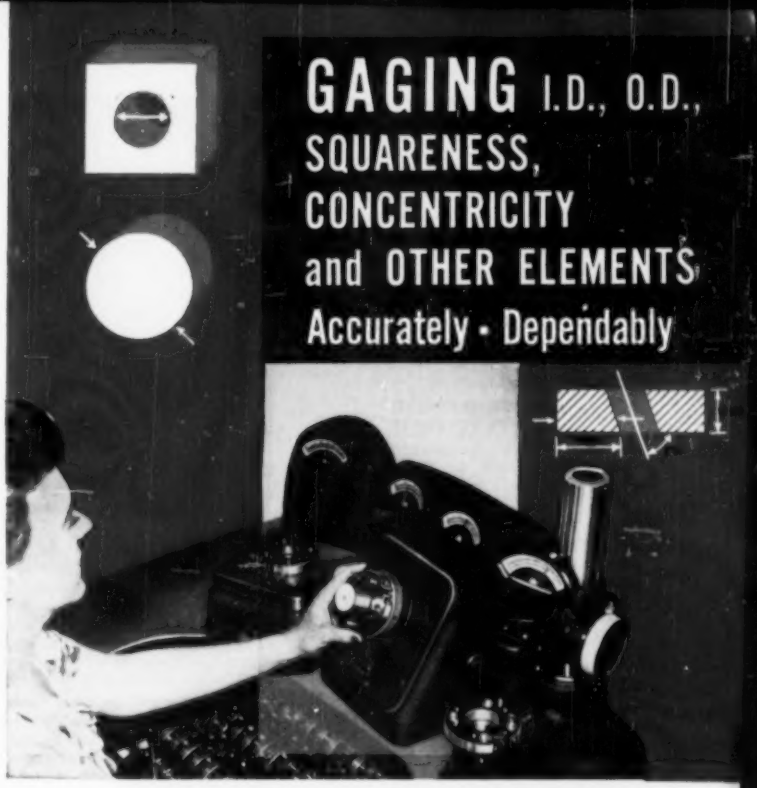
New type tool room measuring instruments such as Leadcheks, height gages, internal and external measuring machines, and taper measuring machines will be shown at the exhibit. Various column and dial Precisionaire production gaging applications as well as visual gages will be included. The Micronaire for measuring textile fiber fineness will be in operation.

Competent gage engineers will be on hand to confer with those who are interested in this type of equipment.

Booths 34-35-36

JOHNSON GAGE

The Johnson Gage Company exhibit is based on the Johnson system of screw-thread gaging and quality control. It will include "fixed"-type ring and snap gages for conventional inspection and "attributes"-type quality control, and "indicating"-type comparators



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PRATT & WHITNEY

Electrolimit COMPARATORS

Pratt & Whitney *Electrolimit* Comparators combine mechanical gaging with an electrical magnification that allows easy and accurate reading of errors to millionths, if desired. Widely used throughout industry, they can be adapted by special scales, magnifications and small detail changes to an almost infinite variety of gaging jobs. Many are used directly on production machinery and inspection lines — others possessing extra sensitivity are used in standards rooms for checking shop or working gages. All are rigidly and accurately constructed and are fast and easy to use. The element of human error has practically been eliminated.

If you have a gaging problem, consult our Gage Engineers. Send today for your copies of Bulletins 499-1 and 481-2. Just write on your Company letterhead to the P & W Branch Office nearest you or direct to West Hartford.

Bulletin 481-2

Bulletin 499-1

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DIVISION NILES-BEMENT-POND COMPANY
WEST HARTFORD 1, CONNECTICUT, U. S. A.

First Choice for Accuracy

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ROCHESTER · SAN FRANCISCO · ST. LOUIS · EXPORT DEPT., WEST HARTFORD

CUTTING TOOLS • GAGES • MACHINE TOOLS

for conventional inspection and "variables"-type quality control. The RING-Snap and ROLL-Snap comparators which will be on display, embody the fundamental principles of Johnson Gage design for determining screw-thread accuracy and assemble-ability. Also included will be various special comparator applications involving squareness and concentricity checks. The Johnson "Setting and Wear-check" plug gages—means for determining degree and type of wear in thread gages and comparators—will also be exhibited.

Booth 38

MICROMETRICAL MANUFACTURING

Micrometrical Manufacturing Company will exhibit the Profilometer in use on machined and ground surfaces of all types. Instant determination of the average surface roughness on sizes from 5/64 in. ID to flat and from flat to 1/16 in. OD. Demonstration of equipment to make measurements in such hard-to-get-to places as resessed bosses, slots in ID's, recessed shoulders, screw threads, gear teeth, and several feet down inside ½ in. ID's and larger.

Mechanical tracing with stroke lengths of $\frac{1}{32}$ in. to $2\frac{3}{4}$ in. Manual tracing with stroke lengths from a fraction of an inch to several feet. Recorder for chart record of point-to-point variation in the average roughness.

Field representatives will be on hand to discuss your special problems.

Booth 40

BRUSH ELECTRONICS

The Brush Electronics Company (formerly The Brush Development Company) will feature at their exhibit of line instruments the "Surfindicator" and "Welding Analyzer."

The Surfindicator, developed by G. M. research engineers, is the answer to measuring surface finish roughness which must be maintained in the manufacturing or machining process.

The Welding Analyzer is used for recording production data, which can be filed and later used for set-ups.

In addition to these two instruments, a few others to be exhibited will be the Uniformity Analyzer, Strain Analyzer, and the Faxfilm Surface Comparator.

Mr. Fred Witzke of the Sales Department, along with other trained engineers from Brush, will be on hand to answer all questions arising from the use of our instruments and their applications to your particular problems.

Booth 42

L. S. STARRETT

The exhibit of The L. S. Starrett Company, Athol, Massachusetts will include a complete line of dial indicators and dial gages for production inspection and quality control.

—Courtesy of Phila. Conv. and Visitors Bureau

Philadelphia Municipal Auditorium—Site of 7th Annual ASQC Convention

In addition will be many other items essential to QC Programs including micrometers of all types, height gages, vernier calipers, gear tool vernier calipers, depth gages and many other precision hand measuring tools.

In attendance at the Starrett booth will be Mr. K. C. Boyer, factory representative in the Philadelphia area; Mr. T. R. Griffith, factory representative in Northeastern Pennsylvania; Mr. R. E. Brackett, dial gage sales engineer, and several factory engineers.

Booth 44

FRIDEN CALTULATING MACHINE

The Friden fully automatic square root calculator will be exhibited and demonstrated on quality control problems, including correlation, analysis of variance, moving averages, standard deviation, correlation coefficient, cube root and fully automatic square root.

The Friden is the world's first and only desk calculator with automatic square root. It provides fully automatic extraction of square root plus all the other time-saving advantages which enable the Friden to do more kinds of figure work without operator decisions than any other calculating machine ever developed.

To extract the square root, the operator merely sets the number on the keyboard, and touches the small key corresponding to the decimal point in the number. The square root appears in the dials almost instantaneously. If desired, the root is retained in the machine for further calculation, eliminating the need for copying the root to the keyboard, with consequent chances for error.

Booth 45

COLLINS MICROFLAT

Collins Microflat Company, Los Angeles, California, will exhibit the Microflat Black Granite Surface Plates. Most uniformly hard granite in the world. Will not warp. Will not rust. No oiling necessary. Cheaper than metal plates. No wringing or lapping of expensive gage blocks and checking fixtures.

Booths 46-47

BRYANT CHUCKING GRINDER

A new line of internal and external thread gages, both portable and bench type, are to be shown by the Bryant Chucking Grinder Company, Springfield, Vt. These gages are built on the principle of an "expanding" master plug for checking internal threads or a "contracting" master ring for checking external threads. Paired segments, one movable, actuate a dial indicator which shows the accumulated amount of variation from basic size. Interchangeable segments cover a range of threads up to 5 in. in all tolerance classes.

Both internal and external bench gages with squareness of over-face or under-face attachments will be demonstrated. These gages are also equipped with an attachment for checking the concentricity of a diameter with the thread.

A portable gage will be shown with plain segments for checking the diameters of "o"-ring and snap-ring grooves.

Booth 48

THWING-ALBERT INSTRUMENT

The Thwing-Albert Instrument Company of Philadelphia will exhibit the following:

1. Electro-hydraulic strain gage tensile strength tester for materials breaking under tension or compression from grams to tons, featuring cyclic operation under load or extension at an infinite range of operating speeds.
2. Handle-O-Meter newly developed instrument for determining the handle or feel of fabrics, papers, etc., measures qualities of friction and flexibility.
3. Treasure Chest portable potentiometer checking and calibrating set with facilities for testing any make or type of pyrometer in plant or laboratory.
4. Elmendorf Tearing Tester for paper, textiles, plastic films, etc., measures serviceablility of materials subject to handling during useful life.
5. Infra-Red Recorder and Bolometer for recording temperatures of surfaces below visible range. No part of instrument is in contact with surface or material to be tested. (Features high sensitivity and high speed of response.)
6. Impact Fatigue Tester, for testing those materials subject to vibration and shock below ultimate strength during shipment and handling. Stainless steel balls are dropped at regular intervals from adjustable heights until failure.

Booths 51-52

MONROE CALCULATING

A new statistics booklet including Monroe methods for advanced statistical calculations such as chi square, skewness, kurtosis, and regression is to be introduced at the convention and will be available at the Monroe exhibit. Our well known booklet, "Quality Control," will also be available for those who have not yet seen it.

Then Monroe Statistical Calculator and Monroe Dual Register Adding Machine—the perfect quality control computing team—will be the center of attraction at the exhibit. Monroe's Statistical Calculator offers an improved automatic squaring lock, a veeder counter for registering the number of items squared and special upper dials which show individual as well as accumulated values. The Monroe Dual Register Adding Machine aids statistical calculations by recording data in a convenient, rapid and accurate manner.

These machines and other Monroe calculating equipment will be on hand for demonstration.

Booths 55-56

BAUSCH & LOMB OPTICAL

The Bausch & Lomb Optical Company is exhibiting at this convention optical instruments which are particularly adapted for the control of quality in the production of an infinite number of items.

All of the instruments embody design principles which time and use have proven definitely sound. Many were originally developed by the Bausch & Lomb engineering staff because of the need for rigid quality control required in maintaining the high standards which are imperative in the manufacture of optical products.

Among the instruments shown and available for demonstration are the Contour Measuring Projector; Toolmakers' Microscope; Stereomicroscope; Balcrometer, or 3 in. direct measuring instrument; Shop Microscope; Brinell Microscope; and a recently redesigned line of wide-field tube microscopes to which has been added a new microscope stand.

Booths 57-58

FORD MOTOR

In order for a QC program to operate effectively, the basic fundamentals must be understood by all levels of personnel; namely, management, supervision, inspectors, and production workers. The Ford Motor Company Training Department, in cooperation with the Quality Control Office, has developed training programs for this purpose. These training programs will be shown at the Ford Exhibit.

A special attraction will be the Machine Capabilities Analysis Program as used by Ford of Canada.

Methods of SQC as used in receiving inspection, machining and processing, and assembly operations will give a general picture of how a complete QC program will operate.

The series of pamphlets on Chart Control will again be available for distribution, and representatives from the Quality Control Office will be at the booth to answer any questions which you may have.

Booths 63-64

TUBULAR MICROMETER

The Tubular Micrometer Company exhibit will consist of a variety of different types of measuring instruments adaptable to the quality control program of the manufacturing and machine tool industry.

The exhibit will consists of micrometers of all types with inside measurements ranging from 0.200 to 106 in. standard and outside measurements ranging from ½ to 168 in. standard, vernier tools of all types, rules and scales, snap gages, dial gages, dial indicators, dial indicator tool adaptations, machine tool checking equipment, dial bore gages as well as a variety of special adaptations of standard measuring instruments.

Samples of special applications which have been made up for American industry will be displayed as well as prints and photographs which will enable prospective users to ascertain the variety of applications to which the tubular steel construction can be placed.

Booth 67

SERVICE DIAMOND TOOL

The Service Diamond Tool Company, Ferndale, Mich., announces the introduction of a new, improved hardness tester for Rockwell Testing. Among the many features are:

1. *Accuracy*
   a. More closely calibrated for Rockwell Testing.
   b. Thread-ground elevating screw lapped in with 4-in. long hardened and ground bushing for precision alignment.
   c. Patented spindle construction for maximum constraint, coupled with minimum friction.
   d. Interchangeable weights, bright chrome, suspended with ball-socket joint for perfect alignment.
2. *Rugged Construction and Smooth Operation*
   a. Generous, oversize sections in casting. Less frame deflection than any other machine for Rockwell testing.
   b. One compact linkage and dash pot sub-assembly with all components of extra heavy construction; machined from solid metal; no die castings. All bearing surfaces are lapped for practically frictionless operation and the speed of operation is regulated by a simple, adjustable, easy-to-reach needle valve.
   c. Every single moving part is enclosed and dust-proof, yet can be reached through a large, hinged door in the side of the casting.

CHICAGO QC COURSE

The eighth short course in SQC by W. E. Jones and Management Controls will be given at the Hotel Sherman, Chicago, Ill. from March 27 through April 4.

For information about this course, write to W. E. Jones, 1365 Webford Ave., Des Plaines, Ill. or phone VAnderbilt 4-1317.

(Advertisement)

A new book that explains Statistical Quality Control in the broad sense; nontechnical, explanatory for executives and nonstatisticians.

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OF QUALITY
By W. Edwards Deming
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Control Charts Using Midranges and Medians*

ENOCH B. FERRELL

Bell Telephone Laboratories, Inc.

ABSTRACT

The midrange of a sample or subgroup is half the sum of the largest and smallest. Like the mean and the median it is a central value. This article proposes that control charts be constructed using ranges and midranges within subgroups and medians of these statistics between subgroups. Under conditions of statistical control, these statistics are somewhat less efficient than those usually employed to estimate the parameters of a parent universe. But it often happens that a set of data comprises, in addition to those observations that represent a common parent universe, some observations that represent disturbances or assignable causes of variation. Under these conditions the method proposed tends to give more useful estimates of the universe parameters. It also tends to be more effective in detecting and locating such disturbances. It involves simpler computation and hence invites analysis of data on the spot, rather than as a separate and subsequent operation.

THE PROBLEMS OF STATISTICS

When control charts were first used, they were charts of the averages and standard deviations of small samples or subgroups. But the standard deviation soon gave way to the range. This was partly because it is easier to compute, and partly because it does a better job of locating common types of trouble. This article proposes a further step in that direction through the use of the midrange and the median. Specifically, it proposes the use of the midrange within subgroups and of the median between subgroups.

What are the functions of statistical analysis as it applies to the control of manufacture or the control of experimentation? What are the problems it should seek to solve? Let me describe four problems which are illustrated in Fig. 1.

First, given a number of pieces of information; summarize this information in a very few numbers. This summary can be made by stating a central value such as the mean, by

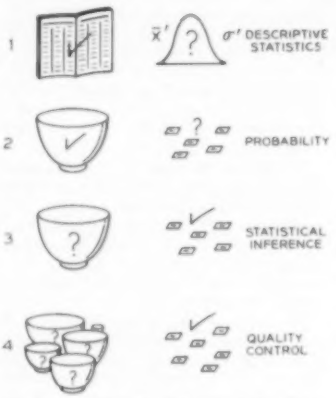

Figure 1—**The Problems of the Statistician**

stating a dispersion such as the standard deviation, and so on. At one time it was fashionable to summarize by means of an analytic or algebraic expression for a frequency distribution. These are all summaries of existing data. We can call this descriptive statistics.

Second, given a bowl full of numbers—a population or universe—about which we know everything, and from which samples are to be drawn in the future; predict the characteristics of these samples. We call this probability *a priori*.

Third, given a bowl full of numbers about which we know little or nothing—a universe with unknown parameters—and given a sample that has been drawn from that bowl and about which we know everything; estimate the parameters of the universe in the bowl. We call this statistical inference.

Fourth, given a set of observations about which we know everything; was there a bowl? Let me say this another way: given what is supposed to be a sample from a universe, could this reasonably be a random sample from a single universe, or should it be treated as a set of subsamples from several universes with perhaps a few wild shots thrown in? This is the basic statistical problem of the QC man. We do not have a name for it. We need one.

In developing the theories and techniques we must tackle these problems in the order given. We must first develop a language or method of description. Then we can state and solve probability problems in a mathematical, rigorous manner. We can set up mathematical models that nearly everybody agrees are definite. We can, in general, set up physical models which nearly everyone agrees are closely analogous to the mathematical models.

We do not know how to attack the third problem directly. We do not have anything like complete agreement as to what mathematical models would be interesting, or more nearly analogous to situations we find in the physical world. We see the third problem only as the inverse of the second.

The fourth problem is really an attack on the question of what mathematical models, *if any*, fit the physical situation. Our usual method is to try two or more models and study the consistency or inconsistency among the results obtained.

The working engineer or physicist or economist must, except for the language problem, tackle these problems in the reverse order. He never knows what is in the bowl; he is never even sure that there was a bowl. He has only the numbers that he hopes form a sample. He must first try to determine whe-

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ther or not they do belong to a universe. If not all of them, then do most of them—and which ones? Only after he has answered this fourth question does the third make sense. And only after he has gotten the parameters can he hope to solve the second problem and make a prediction. He must of necessity start at the bottom and work up, whereas the mathematician starts at the top and works down.

THE CONVENTIONAL CONTROL CHARTS

There are various techniques for attacking these problems. One of them is the control chart. It is a system of bookkeeping that attacks all four problems. The points and lines of our control charts form a simple, easily understood descriptive summary of the data. The points inside the control limits indicate which parts of our data, if any, might be usefully treated as belonging to an underlying or inherent universe. The outages show which parts of our data should not be considered to have come from such a universe. The central values of our charts give us estimates of parameters of this underlying universe, if it exists. The limits constitute our predictions as to future samples, if predictions can logically be made.

In the control chart method of analysis we test for consistency by comparing two dispersions. We say, in effect, let's suppose there is a universe. From the average of subgroup ranges we estimate the dispersion of this assumed universe. From this we compute, as though it were a prediction, the dispersion of subgroup averages. Then we compare the observed dispersion of subgroup averages to this "prediction." This comparison is not made on the basis of mean or rms deviations. Instead, we compute an expected extreme deviation—a 3-sigma limit—and then note whether any subgroup average has a deviation from the central line greater than this expected extreme.

Outages, which indicate inconsistencies or disturbances, may arise in several ways: the central value may change, either by a sudden shift, by a slow drift, or in a cyclic or wavy manner; the dispersion may change by a shift, a drift, or a wave; or we may have occasional observations that fall into no recognizable pattern and which we call wild shots.

THE PROPOSED CONTROL CHARTS

Now in estimating the parameters of the universe that we have assumed exists, and which we hope does exist most of the time, we would like to ignore the disturbances. This means ignoring, or at least soft-pedaling, the extremes. We can do this by using medians.

This suggests that we base the estimate of dispersion not on the mean of the ranges, but on the median of the ranges; and that we base our estimate of central value likewise on the median of the central values of the subgroups.

We would like to use very simple computations, particularly for the subgroup statistics which are so numerous.

My suggestion is that within each subgroup we compute the range, which is simply the difference between the two extremes and is a measure of dispersion, and the midrange, which is the mean of the same extremes and is a kind of average; that between subgroups we compute the median of the ranges and the median of the midranges; that we base the control limits on these medians; and that we compare the subgroup ranges and midranges to these control limits. Table I gives the equations of this proposed method together with the symbolism used. The factors needed for computing control charts in this manner are given in Table II. They are based on the use of 3-σ limits and the assumption of normality in an underlying distribution.

There are three objections commonly heard to these proposals: Nobody does it. We don't know anything about the distributions of the median and the midrange. Neither the median nor the midrange is very efficient.

To be sure, little use has been made of the median and midrange in control chart work. But they have been used elsewhere. And we do, in fact, know quite a bit about these statistics. Hastings, Mosteller, Tukey and Winsor, in their very valuable paper "Low Moments for Small Samples," Ann. Math. Stat., Sept. 1947, give parameters from which their means and standard deviations can be computed. They have done this for the Normal universe, for a short-tailed universe, and for a long-tailed universe. Godwin, in "Some Low Moments of Order Statistics," Ann. Math. Stat., June, 1949,

TABLE I—**Basic Equations for Control Charts Using Medians and Midranges**

Estimates:	X'	$= m(M)$
	σ'	$= m(R)/d_4$
3-σ Limits:	$U(L)CL_M$	$= m(M) \pm A_4\, m(R)$
	LCL_R	$= D_3\, m(R)$
	UCL_R	$= D_4\, m(R)$
Where:		
	X'	= Mean of parent universe
	σ'	= Standard deviation of parent universe
	n	= Size of subgroup
	R	= Range of subgroup = Max. − Min.
	M	= Midrange of subgroup = (Max. + Min.)/2
	$m(R)$	= Median of the ranges
	$m(M)$	= Median of the midranges

TABLE II—**Factors for Control Charts Using Ranges, Midranges, and Medians**

n	A_4	d_4	D_3	D_4
2	2.224	0.954	0	3.865
3	1.137	1.588	0	2.745
4	.828	1.978	0	2.375
5	.679	2.257	0	2.179
6	.590	2.472	0	2.055
7	.530	2.645	0.078	1.977
8	.486	2.791	0.139	1.901
9	.453	2.916	0.187	1.850
10	.427	3.024	0.227	1.809

has done the same thing with considerably greater precision for the Normal universe only. We know that if the parent universe is symmetric the midrange and the median form symmetric universes. There is reason to believe that the midrange of small samples from a Normal universe is very nearly normal and that we can assume normality in the midrange with very little error.

In unpublished work Dr. P. S. Olmstead has given the control chart factors for ranges and means based on the median range. A. Hald in *Statistical Tables and Formulas*, John Wiley and Sons, gives considerable information about the distribution of the range of samples from a Normal universe.

COMPARING EFFICIENCIES

Figure 2 illustrates the comparative efficiencies of these various statistics as used in control chart work. Efficiency is used here in the standard sense and relates to the expected dispersion of estimates based on an idealized sampling procedure. For this illustration we assume that we have taken a random sample of ten subgroups of five observations each from a Normal parent universe whose mean is $\bar{X}'$ and whose standard deviation is σ'; that from these samples we have estimated X' and σ'; that from these estimates we have computed control chart limits; and that this whole process has been repeated many times. We expect 95 percent of our estimates to fall within the shaded regions in Fig. 2.

Figure 2a shows the estimates of $\bar{X}'$ and the control chart limits on subgroup means. Computations are based on subgroup ranges and means and on the means of these—the conventional control chart. Figure 2b shows analogous results based on subgroup ranges and midranges and on the medians of these—the method proposed here.

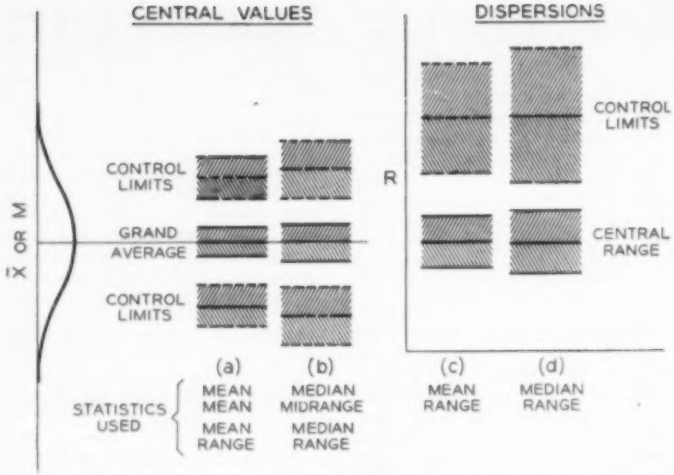

Figure 2—**Estimates of Parent Universe Parameters and of Control Chart Limits**

Estimates are based on random samples, each consisting of ten subgroups of five observations from a normal universe. We expect 95 percent of the estimates to fall within the shaded areas.

Figure 2c shows the estimated dispersion of the parent as measured by the subgroup range, and the control chart limits on the subgroup ranges. Computations are based on the subgroup ranges and their mean. Figures 2d shows analogous results based on subgroup ranges and their median.

MINIMIZING THE ERRORS OF DISTURBANCES

It is apparent that the median is less efficient than the mean *if a state of statistical control exists*. But the usual situation is that disturbances are present, and that they destroy the state of the statistical control. These disturbances introduce errors into our estimates of the parameters of an underlying universe. We need, therefore, a procedure which will minimize these errors in the estimates.

If the disturbances are large, the median does a better job of minimizing than does the mean. Specifically, if the disturbances are larger than those shown in Table III, it pays to use the median midrange and the median range. For smaller disturbances the simple mean is better, but in this case the error is so small that it makes little difference which we use.

In computing Table III three particular situations are considered. Suppose that we have a Normal parent universe, that we have nine subgroups of five taken at random from this universe, and that we have a tenth subgroup of five which has been affected by some assignable cause. Consider three different kinds of disturbances that might affect this tenth subgroup. First, let its central value but not its dispersion be affected. Second, let its dispersion but not its central value be affected. Third, let one single observation be affected and let the other four members of the subgroup have the values to be expected for a sample of four. These three situations are illustrated in Fig. 3.

TABLE III—**Disturbances for Which Equal Error in Estimate is Produced by Proposed and Conventional Methods**

(10 subgroups of 5; one subgroup disturbed)

Nature of Disturbance	Parameter Estimated	Size of Disturbance
Change in Central Value	$\bar{X}'$	$\bar{X}'_{dist} = \bar{X}' + 0.70\sigma'$
Change in Dispersion	σ'	$\sigma'_{dist} = 1.53\sigma'$
Wild Shot	$\bar{X}'$	$W = \bar{X}' + 3.50\sigma'$
	σ'	$W = \bar{X}' + 2.53\sigma'$

$\bar{X}'$, σ': parameters of a Normal parent universe. $\bar{X}'_{dist}$, σ'_{dist}: parameters of a disturbed universe that exists for one subgroup only. W: a single wild shot.

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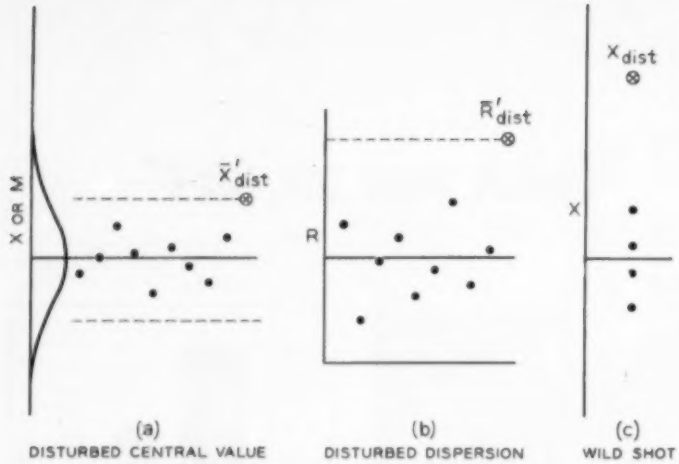

Figure 3—Types of Simple Disturbances

These are obtained from idealized mathematical models with minimum detectable disturbances.

For each of these situations, we have computed the magnitude of the disturbance for which the expected error in estimation is the same if we use midranges and medians as it is if we use means. For larger disturbances the midrange-median combination involves less error in estimation, on the average, than the conventional method.

LOCATING A DISTURBANCE

In addition to, and more important than, minimizing these errors in estimation caused by disturbances, we are interested in locating the disturbances. To compare the two methods of computing control charts in this respect, we ask about each: What is the minimum disturbance that will produce a control chart outage? And we ask this question for each of the three particular situations already studied. Table IV gives these minimum detectable disturbances.

The upper line in Table IV shows that a shift in central value of $\pm 1.48\sigma'$ which affects a single subgroup has a 50-50 chance of producing a control chart outage if means are used in computing the limits. If medians and midranges are used, the required shift is $\pm 1.60\sigma'$. This indicates that the conventional chart is about 8 percent better for detecting disturbance of the central value than the method proposed here.

The second line shows that in a range chart based on the mean of the ranges a change in dispersion from σ' to $2.41\sigma'$ will be detected about half the time if only a single subgroup in the ten is affected. If the control limits are based on the median of the ranges, this figure is reduced to $2.23\sigma'$. This is an improvement by about 8 percent.

The lower two lines show that in detecting a wild shot the conventional control chart of means is almost worthless. The conventional range chart is fairly good. The control chart of midranges proposed here is about 4 percent better, while a 10 percent improvement is obtained with a range chart whose limits are based on the median range.

These computations, of course, are an example based on a particular mathematical model and use some approximations. They are not a rigorous proof. What they indiacte is that the proposed control charts tend to be as useful, and in some situations more useful, than the conventional charts. We should not fear to use them because of supposed inefficiencies.

SPEED AND SIMPLICITY

There is another, and I think stronger, reason for using the proposed methods. They involve simpler and easier computations. We commonly locate the extremes of a subgroup in order to compute the range. Let us use the same two extremes to compute the central value.

Even though four is often thought to be a little more effective, subgroups of five are used a great deal, because the computation of the average is easier. You add the five numbers, multiply by two and shift the decimal point. In the proposed scheme you add the two extremes and divide by two. In the laboratory where a large amount of data analysis is done, you soon develop the habit of simply looking at the two extremes and writing down the number half way between them, without any formal addition and division. And with the proposed method this process is exactly the same whether the subgroup size is five, or four, or any other number.

This simplification of computation is most important, because it makes it that much easier for the operator to compute the control chart on the spot and to use its information immediately. Promptness in detecting troubles would be worth a considerable decrease in numerical precision, but in the proposal presented here there is little or no sacrifice in precision.

TABLE IV—**Minimum Disturbance to Produce Control Chart Outage**
(10 subgroups of 5; one subgroup disturbed)

Nature of Disturbance	Statistics Used	Magnitude of Disturbance
Change in Central Value	$\bar{X}, \tilde{X}, \tilde{R}$ M, m(M), m(R)	$\bar{X}'_{dist} = \bar{X}' \pm 1.48\sigma'$ $\tilde{X}'_{dist} = \tilde{X}' \pm 1.60\sigma'$
Change in Dispersion	R, $\bar{R}$ R, m(R)	$\sigma'_{dist} = 2.41\sigma'$ $\sigma'_{dist} = 2.23\sigma'$
Wild Shot	$\bar{X}, \tilde{X}, \tilde{R}$ M, m(M), m(R)	$\bar{X}'_{dist} = \bar{X}' \pm 10.36\sigma'$ $\tilde{X}'_{dist} = \tilde{X}' \pm 4.40\sigma'$
Wild Shot	R, $\bar{R}$ R, m(R)	$\sigma'_{dist} = 4.58\sigma'$ $\sigma'_{dist} = 4.15\sigma'$

$\bar{X}'$, σ': parameters of a Normal parent universe. $\bar{X}'_{dist}$, σ'_{dist}: parameters of a disturbed universe that exists for one subgroup only. W: a single wild shot.

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Psychological Aspects of a Control Chart Installation

K. A. LIFSON
DALLAS, TEXAS

Whenever the result of an investigation is a proposed system involving changes in what people do or the way people do things, the success of the proposed system depends largely on how the people feel about changing their ways. The installation of statistical quality control charts does mean such a change, and no matter how carefully the system is devised and the technical details calculated, the charts will not work unless the people whose jobs they affect want them to work.

This article discusses some of the techniques which, for the author, have been successful in helping to secure cooperation in control chart installations.

EXAMPLE FROM A FOOD-PACKING PLANT

The particular installation discussed here was in a food-packing plant. In this plant, jars were filled with product by passing them under one of a battery of six spouts. The amount of product was volumetrically controlled. Fine adjusting screws controlled the volume of each spout, and there was a gross adjustment for the whole battery. Because the density of the product changed, frequent adjustments were necessary. On each shift, one girl was made responsible for controlling the weights, and about one third of her time was available for this work. To check the weights, the operator weighed six empty jars, placed them on the conveyor in such an order that they would be filled simultaneously, weighed them after they were full, and recorded the net weights on a form. She made adjustments to the filling machine as she saw fit.

CONTROL CHARTS WERE INDICATED

Data on the net product weights revealed the possibility of effecting a reduction in both the average overweight per jar and the number of underweight jars, by reducing the variation in product weights. Much of the variation was due to assignable causes: differences among the spouts, between the operators, and between the styles of product packed. Also, the residual variance was out-of-control, and definite trends in both the average and the variation were revealed. Control charts were proposed to reduce the variation of the weights. The system was tentatively "sold" to management on the basis of the ability of the charts to do three things. First, they would be graphic, easily-read records of performance. Where they are records of operator performance, as in this case, the operator could be proud (or ashamed) of the record. Second, they would point out trends in the data which are otherwise difficult to notice. Third, the control limits would provide definite bases for machine adjustment.

The statistical work of analyzing the variance and computing tentative control chart limits took two weeks. Instituting the changes took eight weeks, more or less divided into four phases: becoming accepted, getting the program accepted by supervision and by the operators, training a supervisor to maintain the program, and follow-up work.

BECOMING ACCEPTED

The first step in any such investigation should be an effort by the investigator to become accepted by the people who will provide him with information and who eventually will have their activities affected by the results of the investigation. Several techniques and approaches were used in the case being discussed to gain acceptance by the girls who did the weighing.

The initial approach was to explain that assistance of the sort being offered had been of value in similar situations, and *might possibly* do some good here. If one says he *is* going to do something, the workers feel that it is entirely out of their hands, and take no active part in experimenting or cooperating. Some will actually delight in showing that what has been said *would* be done actually will *not* be done. The "might possibly" approach works better. It does not leave the quality control man in the position of an all-powerful prophet, but rather puts him on a more equal plane with the workers. This is certainly more conducive to cooperation.

Some immediate explanation of the possible programs of quality control was offered. Questions the girls had were answered fully. This served the purpose of stimulating some interest in which program would work best, and it also allayed any fears the girls had that their jobs would be greatly altered or eliminated.

Frequent mention was made that the girls were doing a good job on the weights—as good as possible with the present equipment and system. This was true.

Learning how to perform the girls' jobs was necessary in order to determine possible equipment changes. This process also served as an "equalizer," as the girls were in the "teacher" role and the investigator was in the "learner" role. While "learning" the task, he did not allow himself to proceed too rapidly, and commented on the difficulty.

After having learned the task, the quality control man performed it to gather some of his data. The gathering of his own data contrasted favorably with the previous practice of having supervision impose upon the girls to gather data in addition to their regular duties.

It seemed that a more favorable impression was made when "coffee time" was spent in the factory coffee room engaged in "small talk" with the operators, rather than going to the executive coffee room.

As much as possible, the quality control man played on the fact that while he was with them, the girls' jobs were more interesting than usual. This is a very important factor. An "outsider's" presence was something out of the ordinary, and he tried to make it interesting.

GETTING THE PROGRAM ACCEPTED BY SUPERVISION

After personal acceptance was gained and the particular control chart technique to use had been decided upon, it was necessary to get supervision to accept and use the system. The approach used was that

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the system was an effective aid for them in maintaining good weights.

As was to be expected, the investigation caused the foremen who were in charge of the weights to redouble their efforts by changing gaskets, etc. This was reacted to with applause, instead of the air of competition which they may have expected.

To illustrate how the control charts were operated, the foremen and higher executives were called to a meeting where they each made a chart. Poker chips were marked with representative weights and the group participated in drawing the chips. A normal universe in control was used, then the average was raised and lowered and finally the process was caused to go out of control. This meeting was successful both for "selling" the charts and for illustrating how they work and are interpreted. Having the group actually do it works much better than merely talking about it.

Later, examples of actual charts were used to reinforce what had been learned in the poker chip session. The foremen were shown how to use the charts to evaluate the girls' efforts. Actual charts which pictured what happened when the operator ignored a trend were contrasted with actual charts on which the proper adjustment had been made. Those which pictured what happened when a battery volume adjustment was made were contrasted with ones on which spout adjustments were made. From these the foremen were shown how to recognize which adjustment had been indicated as being necessary.

Other examples were shown to enable the foremen to use the charts in determining the condition of the filling machine. Examples of charts which indicated loose gaskets, poor vacuum, and other malfunctions were gone over several times.

GETTING THE PROGRAM ACCEPTED BY THE OPERATORS

The routine of the operators was changed by the system. In addition to recording the six weights of the sample, they were required to compute the total of the six and the range, and to plot these values on charts. Also, they had to learn to follow the control charts and to decide from them when each type of adjustment was necessary or when the foreman was to be consulted.

One of the most important factors in the successful operation of a control chart system is the acceptance, by the operators, of the charts as being part of *their* job. They must be "ego-involved" with the system. They must think and speak of the charts as *my* charts just as they think and speak of *my* machine or *my* work bench.

Several techniques and approaches were used to get the girls to accept the charts.

The computations were made as simple as possible by using total and range rather than mean and standard deviation. Because the weight was shown on the scale as net difference from a tare, the weights were both positive and negative, and they were usually one digit numbers. Previously, the girls had been recording weights to half of a unit, but

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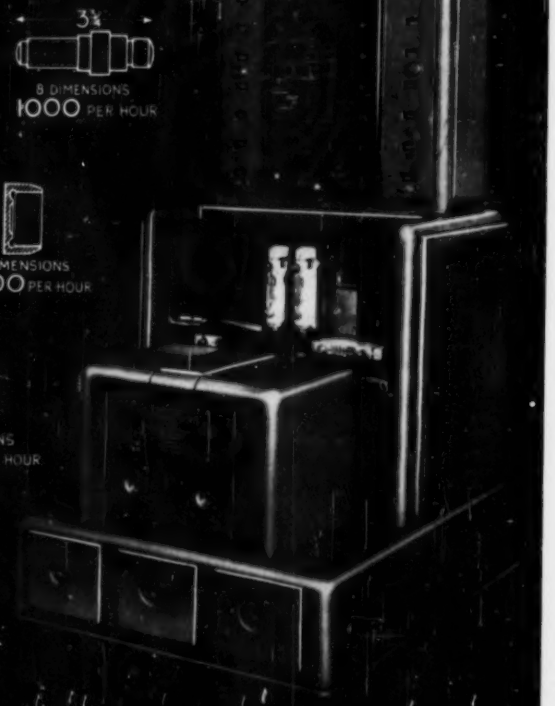

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this was not within the accuracy of the equipment. For the charts, the operators weighed to the nearest whole unit. This change made the task much easier.

Some motion economy and some new minor equipment were introduced which made the job actually less work than it had been. A second scale was suggested which eliminated much walking back and forth. The foreman and the girls had been asking for this for some time, but it took an "outsider" to get it. This was fortunate, since the new equipment was connected in their minds with the control charts. Also, racks for holding the record and a windshield for the scale (which was in a breezy spot) were suggested, resulting in less time per weight.

There had been a policy of not allowing the girls to pick up the empty jars by hooking their fingers inside. This policy was generally being disregarded because there was no other efficient way of handling jars. People feel bad about disobeying company policy even when they know the policy is meaningless. The policy was changed after an investigation for bacteria showed that it could be.

A time study showed that the additional work required actually took the girls only about half a minute longer, even at first. Later, with the equipment changes, the new way took less time than the old. However the girls were told that it was realized the job *would* be more difficult at first but that it would result in better weights. The appeal to pride in the weights worked because of the splendid management-employee relationship at the firm.

Telling the girls that it would be somewhat more difficult seemed to work in preventing them from telling the investigator that. The latter action would possibly result in their *proving* that it was more difficult.

The change was eased along by the quality control man doing the regular work while the girls did the new work. It is essential that the operators begin plotting the points themselves. This seems to create interest in where the next point is going to be and how the day's charts will look. Assistance with regular duties was continued until the girls volunteered that they could handle it all.

After the girls were doing all the work, the follow-up was at first frequent and then gradually diminished. The follow-up consisted of conversation and comments on the charts and being present when the foreman discussed the charts with the girls.

One of the supervisors, who happened to be a chemist, was taught the techniques necessary to maintain the charts. He was taught to calculate means, ranges, control charts limits, accuracy of the mean, standard deviations, and other techniques which he could use not only to maintain the control charts but also in his chemical work. The training was accomplished by using examples from his work. A typical training session included 20 minutes of discussion on problems he had done on the last topic, 20 minutes of discussion on a new topic, and 10 minutes review and discussion of how the new topic fitted in with previous material. Eight such sessions were required.

SUMMARY

This system was successful. It reduced the proportion of underweight jars to an insignificant figure, and it reduced the average overweight per jar enough to mean a large yearly saving in cost of goods manufactured. But the system would not have worked if the foreman had disregarded the charts, or if the operators had complained that they could not add positive and negative numbers, or if they had made intentional "mistakes" in plotting points. Control charts need the cooperation of the people who ultimately must use them.

Bibliography

JOSEPH MOVSHIN, Editor

Assisted by the Editorial Committee, St. Louis Section, ASQC

On matters concerning the Bibliography Department, send correspondence, suggestions, and contributions to:
Mr. Joseph Movshin
9220 Old Bonhomme Road
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APPLICATION—AUTOMOTIVE INDUSTRY

STATISTICAL QUALITY CONTROL AT WORK AT THE CADILLAC TANK PLANT (Tooling and Production—v. XIII, n. 8, Nov. 1952, p. 68)

This article discusses the analysis of several average and range charts rather than their preparation. Such analysis and use of control charts is the key to their value.

APPLICATION—FOOD INDUSTRIES

QUALITY CONTROL SIMPLIFIED FOR PRACTICAL PRODUCT IMPROVEMENT, Amihud Kramer, University of Maryland, College Park, Maryland. (Food Engineering—v. 24, n. 12, Dec. 1952, p. 100)

This article outlines many statistical techniques that can be applied to the food processing industries. These are illustrated with many examples dealing with the canning of vegetables, peanut butter, soluble coffee, juices, etc., as well as equipment such as froth flotation washers, apple peelers and cooling canals. Several intresting tables are provided for evaluation of comparative tests and numerous examples of comparative and panel tests of food products are given. Some of the methods outlined include sampling by attributes, sampling by variables, control charts, measures of significance, paired comparison by attributes, triangular comparison by attributes, multiple comparison, correlation and experimental design.

APPLICATION—METALLURGICAL INDUSTRY

A STATISTICAL ANALYSIS OF THE MECHANICAL PROPERTIES OF CAST AND WROUGHT GOLD DENTAL ALLOYS, S. H. Bush, Instructor, School of Dentistry, University of Michigan, Ann Arbor, Mich.

(ASTM Bulletin—n. 185, Oct. 1952, p. 46)

The results of a statistical analysis on certain mechanical properties of cast and wrought gold dental alloys. Correlations between proportional limit, tensile strength, and Brinell hardness are established. Five per cent limits of error are also shown. Description of the correlation methods used is given.

YOUR QUALITY CONTROL PROGRAM—IS IT EFFECTIVE?, Kenneth MacKay Smith (Foundry—v. 80, n. 10, Oct. 1952, p. 188)

A discussion of the function of quality control in a foundry. The organization for quality control and its relationship to other activities is presented. Not statistical quality control.

APPLICATION—MISCELLANEOUS

HOW A SYSTEM OF CONTINUOUS SCIENTIFIC SAMPLING IS USED TO CONTROL ACCURACY IN LARGE-SCALE INVOICING, R. B. Shartle, Coordinator Office Service Departments, The Standard Register Company
(The Journal of Accounting—v. 94, n. 2, Aug. 1952, p. 167)

Quality control can be applied to office as well as factory operations. Here is a discussion of a system of accuracy control in the invoicing operations at the Standard Register Company. Scientific (statistical) sampling plans are used based upon acceptable quality limits and risks. A control chart is used with this application. Average outgoing quality approach is also used in that the relative quality is improved by the mistakes caught and corrected by the inspector.

CHI SQUARE

THE CHI-SQUARE TEST OF GOODNESS OF FIT, W. G. Cochran
(Annals of Math. Stat.—v. 23, Sept. 1953, p. 315)

This article summarizes information on the chi-square test of goodness of fit. The material is presented in practical terms with a minimum of mathematic development. Discussed are:

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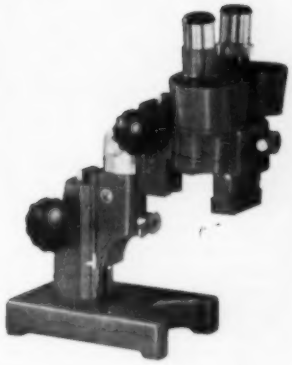

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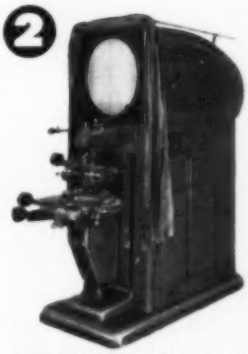

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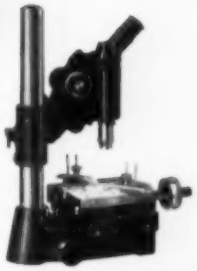

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4. Substitute test for chi square
5. Supplemental tests for chi square

ENGINEERING & EXPERIMENTS

MATHEMATICAL ANALYSIS OF SIZE-FREQUENCY DISTRIBUTIONS OF PARTICLES IN THE SUBSIEVE RANGE, E. E. Petersen, P. L. Walker, C. C. Wright
(ASTM Bulletin—n. 183, July 1952, p. 70)

A method is developed by which the microscopic classification of particles into frequency distribution is developed. This is especially useful for samples containing a wide range of sizes. From this, surface area and weight distribution can be found. A statistical analysis of count data for coal samples for a wide range of sizes is used to verify the reproducibility of these calculations.

THE APPLICATION OF STATISTICS TO ENGINEERING PROBLEMS, M. D. J. Brisby
(Engineering—v. 174, n. 4519, Sept. 5, 1952, p. 294)

This article discusses the application of statistics to certain problems in the management of transportation equipment. One example of such an application is in a study of the number of wagons (rail cars) in works (factories) at one time and the problem of keeping lubes and sidings free. Another application, particularly of the use of Gaussian curve, is in the loading of wagons.

MISCELLANEOUS

WHAT'S AHEAD IN THE NEXT TEN YEARS
(American Machinist—v. 96, n. 24, Mid-November, 1952, Section I)

This 75th Anniversary issue contains a series of reports on current trends in inspection and quality control. The headings discussed under inspection and testing include gaging methods, quality control (statistical), metallurgical control, and statistical techniques. Under quality control, the major trends include the widespread application of statistical methods, educational and training programs, greater emphasis on simpler techniques, more process control in the smaller shops, increased sampling by variables, more production scheduling according to machine capability studies, acceptance of purchased goods on the basis of vendor-supplied control charts, wider use of measuring instruments, greater mechanization of control procedures on selected processes.

Under statistical techniques, education, more sampling by variables, more mechanization of inspection and control by individual values are the trend. Economics will also be stressed.

SAMPLING PLANS AND RELATED TOPICS

PRACTICE VS. THEORY IN SAMPLING INSPECTION, Henry P. Goode, Associate Professor of Mechanical Engineering, Stanford University, Palo Alto, California
(Journ. of Ind. Eng.—v. 3, n. 3, Nov. 1952, p. 17)

Mr. Goode presents in clear detail much of the theory and methodology of practical sampling. Operating characteristics are discussed and used to describe effects of change in sample size and change in acceptance numbers.

Interesting topics discussed are:

Objectives and choice of plan
Choice of a quality level that is acceptable
Choice of OC Curve slope
Choice of type of sampling
Choice of method for item inspected (attributes or variables plan)
Formation of inspection lots

"CUMULATIVE SAMPLING" BOOSTS SHOP OUTPUT 22%, Clyde H. Latter, Quality Methods Analyst, Solar Aircraft Corporation, San Diego, California.
(American Machinist—v. 96, n. 20, Sept. 29, 1952, p. 95)

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MULTISTATION INSPECTION SCHEMES, Gerald J. Lieberman, Stanford University
(Journ. of Am. Stat. Assoc.—v. 47, n. 259, Sept. 1952, p. 466)

A multistation inspection scheme consists of a set of sampling plans applied to individual characteristics at various stations during the production process. The application of a set of sampling plans to variously classified defects will also fall into this category. This paper discusses the problem of finding a multistation inspection scheme which has an operating characteristic that matches a given one-station sampling plan. The mathematical development of this system is based upon a single-sampling plan and an example of such a table is given.

TABLES

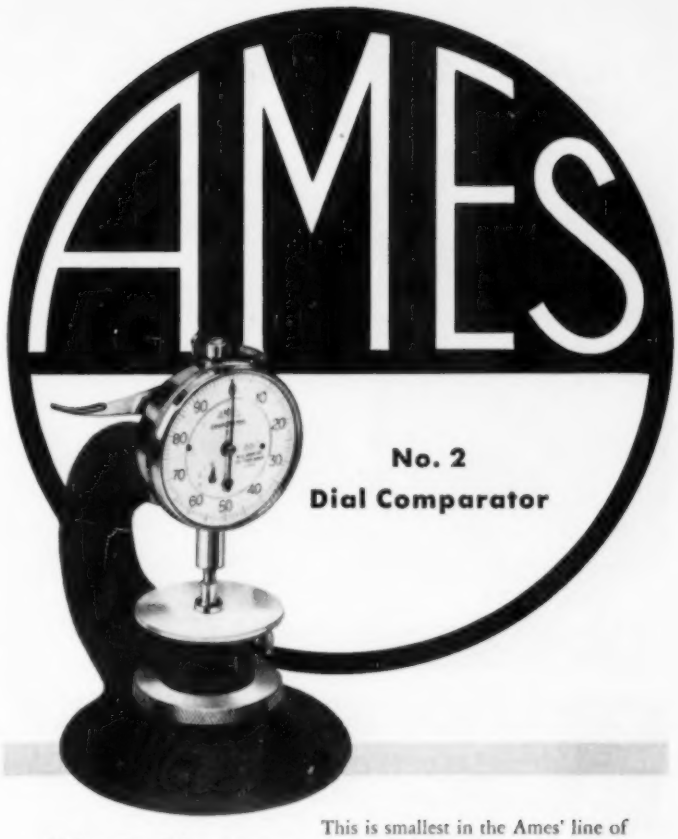
DISTRIBUTION TABLE FOR THE DEVIATION BETWEEN TWO SAMPLE CUMULATIVES, F. J. Massey, Jr.
(Annals of Math. Stat.—v. 23, Sept. 1952, p. 435)

Two tables are given. Table I is for two samples of ten or less and gives the probability of a given deviation between two, small, sample cumulatives. Table II provides similar information for selected additional sample sizes.

THEORY AND APPLICATION—GENERAL

QUALITY CONTROL METHODS, Dorian Shainin, Hamilton Standard Division, United Aircraft Corporation
(PART V. "Building-In Quality," *Machine Design*—v. 24, n. 11, Nov. 1952, p. 160)
(PART VI. "Processes and Natural Tolerances," *Machine Design*—v. 24, n. 12, Dec. 1952, p. 173)

Part V. Sampling inspection is used to evaluate the effectiveness of production equipment and to suggest changes necessary. The fallacy of human judgement in visual inspection is noted. A comparative test of inspection methods is given. The lot-plot is discussed in some detail and some lot-plot charts are illustrated.



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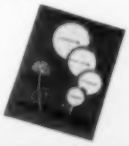
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Part VI discusses natural or process tolerances and their determination through statistical methods. The chart for defects is also considered. A method of finding natural tolerances for destructive tests is discussed, as is continuous sampling by attributes. This article concludes with comment on the classification of defect by designer.

Parts I through IV are reported in previous issues of *Industrial Quality Control.*

STATISTICAL EVALUATION OF RATIONAL AND STRATIFIED METHODS OF SAMPLING, Dr. James V. Strela, Thompson Products, Inc.
(The Tool Engineer—v. XXIX, n. 5 and 6)
Part IV. Nov. 1952, p. 57
Part V. Dec. 1952, p. 70

Part IV. The X and R chart is further discussed. The detection of different processes (or process changes) by this chart is illustrated. The method of sampling is considered throughout as is the detailed effects of ranges in control chart work.

Part V. This article, which is actually the last in the series of five parts of the same paper, compares rational and stratified sampling for liberal and tight specifications. An interesting chart showing component and combined distribution estimated from average and range of 40 rational and 25 stratified samples is given.

Parts I through III are reported in the January 1953 issue of *Industrial Quality Control.*

STATISTICAL METHODS IN INDUSTRY, Dr. James H. Davidson
(General Electric Review—v. 55, n. 5, Sept. 1951, p. 46)

Mr. Davidson discusses the background and application of statistical methods in industry. Five separate fields of endeavor are reviewed.

1. Process Control (Control Charts)
2. Sampling and Inspection (OC Curve)
3. Commercial and Accounting Application (Cost Control Chart)
4. Design of Experiment and Analysis of Data (Factorial Design—Latin Square Design)
5. Research on New Methods (Sampling table for life tests)

TRAINING AND EDUCATION

AN APTITUDE TEST FOR PREDICTING SUCCESS IN A FIRST COURSE IN STATICS. D. F. Votaw, Sr., Southwest Texas State Teachers College, San Marcos, Texas
(Jour. of Am. Stat. Assoc.—v. 47, n. 259, Sept. 1952, p. 516)

The development of an aptitude test to estimate success in elementary courses in statistics is described. The use and need for such a test are considered. Examples of the questions included in the tests are given.

STATISTICS

BOUNDS ON THE DISTRIBUTION OF CHI-SQUARE, S. A. Vora
(Sankhyā—v. 11, pts. 3-4, Dec. 1951, p. 205)

APPLICABILITY OF LARGE SAMPLE TESTS FOR MOVING AVERAGE AND AUTOREGRESSIVE SCHEMES TO SERIES OF SHORT LENGTH—AN EXPERIMENTAL STUDY, A. Matthai
(Sankhyā—v. 11, pts. 3-4, Dec. 1951, p. 218)

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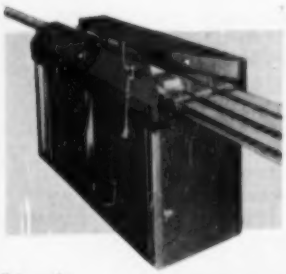

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USE OF COMMERCIAL PUNCHED CARD MACHINES FOR STATISTICAL ANALYSIS WITH SPECIAL REFERENCE TO TIME SERIES PROBLEMS, A. Matthai
(Sankhyā—v. 11, pts. 3-4, Dec. 1951, p. 351)

ON THE ESTIMATION OF VARIANCE AND COVARIANCE, E. H. Lloyd
(Royal Society of Edinburgh, Proc.—v. 63, pt. 3, 1950-1951, p. 280)

SOME ASPECTS OF THE SEQUENTIAL DESIGN OF EXPERIMENTS, H. Robbins
(Am. Math. Soc. Bulletin—v. 58, Sept. 1952, p. 527)

OPERATING CHARACTERISTICS OF THE CONTROL CHART FOR SAMPLE MEANS, E. P. King
(Annals of Math. Stat.—v. 23, Sept. 1952, p. 384)

USE OF PREVIOUS EXPERIENCE IN REACHING STATISTICAL DECISIONS, J. L. Hodges, Jr. and E. L. Lehmann
(Annals of Math. Stat.—v. 23, Sept. 1952, p. 396)

ON THE EXISTENCE OF LEAST FAVORABLE DISTRIBUTION, E. L. Lehmann
(Annal of Math. Stat.—v. 23, Sept. 1952, p. 408)

USE OF TANKS IN A TEST OF SIGNIFICANCE FOR COMPARING TWO TREATMENTS, C. White
(Biometrics—v. 8, March 1952, p. 33)

ON TWO-STAGE SAMPLING, V. P. Godambe
(Royal Stat. Soc., Journal—v. 13, n. 2, 1951, p. 216)

SUBJECTIVE JUDGMENT IN STATISTICAL ANALYSIS: AN EXPERIMENTAL STUDY, D. J. Finney
(Royal Stat. Soc., Journal—v. 13, n. 2, 1951, p. 284)

REPORTED—NOT REVIEWED

ADVANCED STATISTICAL METHODS IN BIOMETRIC RESEARCH by C. Radhakrishra Rao. John Wiley & Sons, Inc., New York. 390 + xvii pp. $7.50.

INSPECTION AND GAGING by C. W. Kennedy. The Industrial Press, New York. 502 + viii pp. $7.50.

CONTROL OF QUALITY ON MASS-PRODUCED ENGINEERING PARTS, J. Loxham (Microtechnic—v. 6, n. 2, 1952, p. 109)

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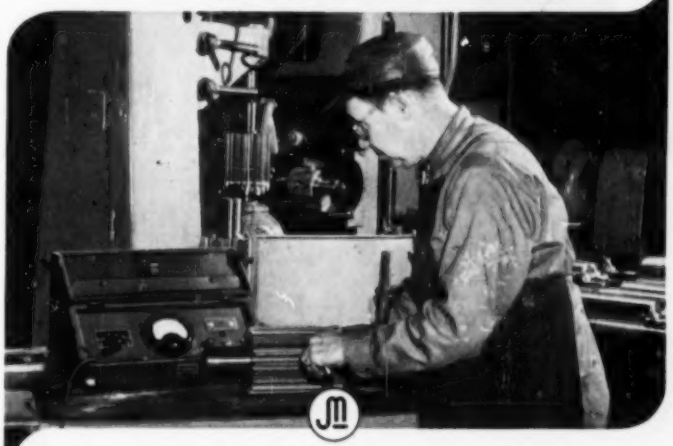

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AMERICAN SOCIETY NEWS

EXECUTIVE COMMITTEE MEETING

The third Executive Committee meeting of 1952-53 was held in New York on Feb. 6 and 7. The following items were approved by the committee:

Section charters have been approved and will be ready for presentation to each section at the Annual Convention.

Also available by convention time will be engraved membership certificates. These will be sent on request of each member at a cost of $3.00.

Effective July 1, 1953, each member of the Society will be billed for his 1953-54 dues on a new form. This form, in addition to showing the coming year's dues, will also include the membership card. In taking this action the Executive Committee hopes to reduce the red tape involved in membership renewals and at the same time eliminate the time lag and possible annoyance in getting membership cards mailed back to renewing members.

The decision was made to print 10,000 copies of the first Standards Committee report, "Definitions and Symbols for Control Charts." One copy of this report will be mailed free to each member. Copies will also be available at the Annual Convention for 50 cents each. The decision was also made to print 1,000 copies of the NSMPA booklet on Mil. Std. 105A which was prepared by Prof. I. W. Burr. This will be available on request at a cost of $1.00 each.

Final approval was given by the Executive Committee to all of the proposed constitutional changes necessitated by the redistricting of the Society. These approved changes will be printed and included with the annual ballot which is mailed to all members prior to the Annual Convention.

New Sections

The two groups which have been admitted to section status since the last meeting are Richmond (No. 63) and Lincoln (No. 64). Officers of the Richmond Section are:

National Director: Clinton W. Baber, Larus Bros., Richmond, Va.
Chairman: Loyal H. Davis, Philip Morris & Co., Ltd., Richmond, Va.
Vice Chairman: Oscar H. Bishop, Reynolds Metals Co., Richmond, Va.
Secretary: Alexander W. Schoenbaum, American Tobacco Co., Richmond, Va.
Treasurer: Tom A. Ligon, E. I. du Pont de Nemours, Richmond, Va.

Those of the Lincoln Section are:
National Director: Homer N. Leymaster, Dempster Mill Mfg. Co., Beatrice, Neb.
Chairman: Edward J. Schaller, Elgin National Watch Co., Lincoln, Neb.
Vice Chairman: Richard B. Weir, National Gypsum Co., Wahoo, Neb.
Sec'ty-Treas.: Irvin L. Reis, University of Nebraska, Lincoln, Neb.

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Also approved at the current meeting was the Kansas City section (No. 65). Officers of this section are:

National Director: H. A. Springer, Sheffield Steel Corp.

Chairman: W. G. Shepherd, Westinghouse Electric Corp.

Vice-Chairman: Wayne E. Burdick, Ford Motor Company

Secretary: Fred E. Fitzgerald, Metallurgical, Inc.

Several requests have been received for information about how to organize a new section. These inquiries have come from Danville, Pa.; Mattoon, Ill.; N. C. State College, Raleigh, N. C.; Sorel, Quebec; and Burlington, Vt.

One of the best ways to get a section started is to become affiliated with the Society as a sub-section of one of the regular sections. This method, of course, has the advantage that the new group can then benefit from the guidance and experience of the parent section. There will always be someone close at hand who can help them with the organization and operation problems that are bound to arise.

Currently active or in the process of formation in the Society are the following sub-sections:

Youngstown (Cleveland)
Long Island (Metropolitan)
New Haven (So. Connecticut)
Berkshire (Albany)
Bay City—Flint—Midland —Saginaw area (Michigan)

Committee Appointments

Shewhart Medal

In the last issue of *Industrial Quality Control* it was incorrectly announced that the resignation of Warren R. Purcell as chairman of this committee had necessitated the appointment of Maj. Gen. Leslie E. Simon.

Mr. Purcell did not resign this post; his 3-year term of office expired.

In view of the nature of this error it would be appropriate here to again express our gratitude to the great number of people who have helped our Society so immeasurably by their faithful service not only on committee work but in many other ways. The number of persons who resign from committee appointments are very few; those who do, do so reluctantly and under the obvious

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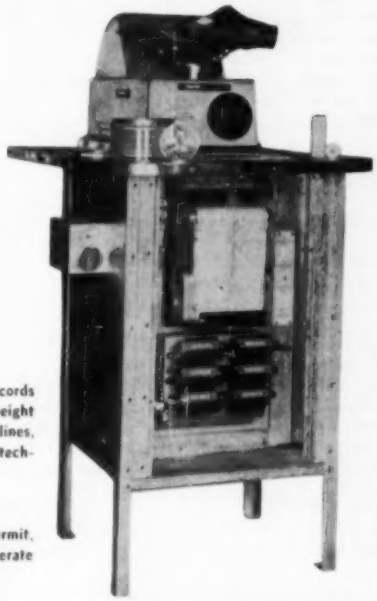
IN INTEGRATING OVERWEIGHT & UNDERWEIGHT AMOUNTS AND UNIT COUNT AMOUNTS INTO SEPARATE ELECTRIC COUNTERS



THE "DATAMATIC" AUTOMATICALLY
does all the work, produces all the records required for statistical or simple weight control at a single or at multiple lines, when using sampling inspection techniques.

THE "DATAMATIC"
(likened unto cash registers) would permit, literally, a 14 year old child to operate S.W.C. for several production lines.

USES ANY CHECKWEIGH SCALE
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ONE "DATAMATIC"
is being successfully used for S.W.C. on 14 production lines (Same product).

ANOTHER "DATAMATIC"
is being successfully used for S.W.C. on
4 production lines (one product)
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Might we suggest you request circular matter.

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pressure of extreme over-work. With this sort of cooperative spirit so prevalent among the members, our Society can't fail to continue its growth in stature and service to industry.

Regional Conferences Coordinating

One of the many and serious problems which develops as our Society grows is that of a conflict of local activities and conferences not only with the national activities but with each other. The conflicts will occur both in timing and in principles. So far the regional activities have been well planned to avoid any serious conflict with the annual conventions, but not so much so to avoid conflicts with each other.

In an attempt to resolve some of the problems arising in the planning of regional conferences, the president has appointed this committee. Its function, of course, will be to review the plans for all regional conferences, to advise the regional planning committees when a conflict occurs, and to recommend any changes in plan necessary to avoid the conflict.

The members appointed to serve on this committee are:

Ervin E. Schiesel, *Chairman*
Clarence R. Burdick
F. J. Halton, Jr.
Wyatt H. Lewis
George R. Page
Wade R. Weaver, *Gen. Conv. Com. liaison*

POSITIONS WANTED

Address all replies to box number references to: American Society for Quality Control Room 5038, 70 East 45th Street, New York 17, N. Y.

INDUSTRIAL ENGINEER—BSIE, 26. Experienced in naval ordnance production and establishment of quality control. Desires connection with medium size company seeking management assistant. Demonstrated ability to work with technical and production people. Available April upon completion of military service as naval lieutenant. Please reply to Box 9E1 at the above address.

Responsible position in Quality Control Field. Grad. M.E., Fellow member ASQC. Five years experience in QC—organizing and supervising. Ten years—Methods, Time Study, Process Eng. Broad experience in metal working industry from mass production to job shop. Salary range 9000. Reply to Box 9E2 at the above address.

Quality Control Manager desires to change to mass production precision field. Many years experience in organizing and administering quality control programs including mass production precision operations, vendor relationships, incoming acceptance, process controls, quality audits, and evaluation of customer experience. Please reply to Box 9E3 at the above address.

Electronic engineer with three years experience in statistical quality control. Member ASQC and IRE. Wishes position in quality control or engineering. Prefer west coast. Reply to Box 9E4 at the above address.

CONTRIBUTIONS TO SHEWHART AND BRUMBAUGH FUNDS

The following contributions have recently been received for the Shewhart Medal and Brumbaugh Award funds:

Shewhart Medal

Michigan	$100.00

Brumbaugh Award

Michigan	$100.00
New England Region	25.00
San Diego	10.00
Rhode Island	10.00

The Society greatly appreciates these contributions which are received from various sections from time to time. The goal for these contributions is to obtain sufficient money in these funds so that they can ultimately become self-sustaining. It is hoped that other sections will be able to make similar contributions in order that this goal can be achieved in the near future.

FILM LIBRARY

Paul A. Robert, assistant chairman of the Program and Speakers Committee, who has charge of the film library, has announced that the two copies of the 2-reel Defense Department films are now available. Sections desiring to order these films should contact Mr. Robert, c/o I. B. M. Co., Endicott, N. Y.

MAILING OF IQC

At the November Executive Committee meeting it was decided to set up a complete mailing list at our printers, Wisconsin Cuneo Press. This action was approved as a means of offering improved service to our members by increasing the speed and efficiency of addressing and mailing the magazines.

This list was set up in December and was first used to mail the January issue. In view of the difficulties which are bound to occur in starting an operation like this, we would like to apologize to those members whose January issues were delayed or possibly even misdelivered. It is hoped and anticipated that virtually all of the "critical defects" were eliminated prior to the mailing of this March issue.

If you have not received your copy of the January issue by the time this arrives or if your address is not correct, please let us know right away. Please address any remarks you might have to George R. Foster, 161 W. Wisconsin Ave., Milwaukee 3, Wis.

CONSULTING SERVICES

Responsibility of the American Society for Quality Control, Inc., for Consulting Services advertising is limited to certification that advertisers hold the grade of membership in the Society stated in their advertisements. Qualification requirements for the several grades of membership are set forth in the Constitution of the Society.

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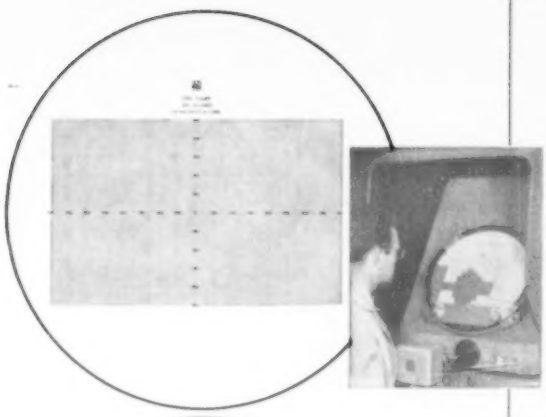

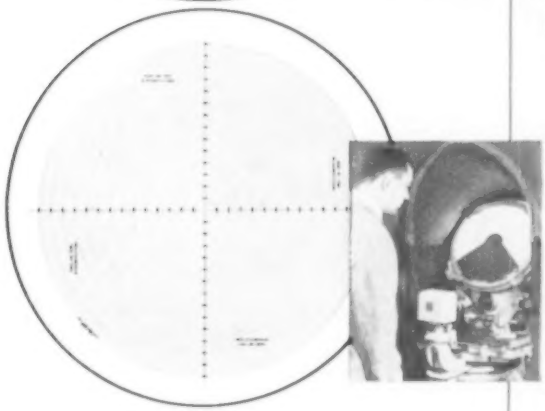

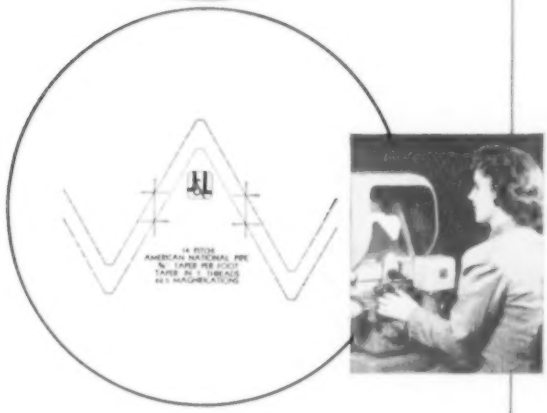

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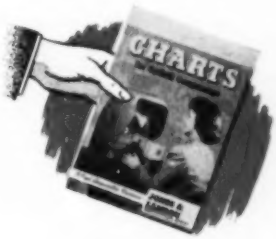

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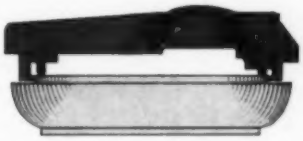
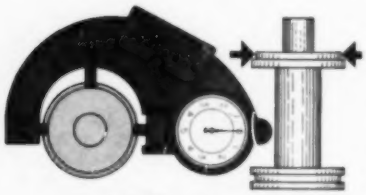


Humped Types
Inside or Outside



"C" Types
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"Locating" contact points help to position the gage parallel to the flat surfaces of the workpiece so the actual diameter is read perpendicular to the axis of the workpiece. Both inside and outside diameters, and diameters at various depths, are checked positively and accurately.

For checking workpieces having projections which would interfere with Straight Type Gages, the Humped Types are recommended. For measuring similar dimensions remotely located from either end of the workpiece, "C" Type Gages are the answer. Let us know your requirements. Federal Products Corporation, Providence 1, Rhode Island.

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